INTEGRATED MISSION PRECISION ATTACK COCKPIT TECHNOLOGY (IMPACT)

PHASE I: IDENTIFYING TECHNOLOGIES FOR AIR-TO-GROUND FIGHTER INTEGRATION

ANTHONY J. MONTECALVO
EVAN P. ROLEK
MARK C. REDDEN
JOHN A. HASSOUN

VEDA INCORPORATED
5200 SPRINGFIELD PIKE, SUITE 200
DAYTON, OH 45431-1255

GREGORY J. BARBATO
WL\FIPC

OCTOBER 1994
FINAL REPORT FOR 04/01/93 - 05/11/94

FLIGHT DYNAMICS DIRECTORATE
WRIGHT LABORATORY
AIR FORCE MATERIEL COMMAND
WRIGHT PATTERSON AFB OH 45433-7562

NOTICE

When government drawings, specifications, or other data are used for any purpose other than in connection with a definitely government-related procurement, the United States Government incurs no responsibility nor any obligation whatsoever. The fact that the government may have formulated, or in any way supplied the said drawings, specifications, or other data, is not to be regarded by implication or otherwise in any manner construed, as licensing the holder or any other person or corporation, or as conveying any rights or permission to manufacture, use, or sell any patented invention that may in any way be related there to.

This report is releasable to the National Technical Information Service (NTIS). At NTIS, it will be available to the general public, including foreign nations.
This technical report has been reviewed and is approved for publication.

Gregory J. Barbato

GREGORY J. BARBATO
IMPACT PROGRAM MANAGER

RICHARD W. MOSS
CHIEF, COCKPIT DEVELOPMENT BRANCH
COCKPIT INTEGRATION DIVISION

Joseph C Von Holle

JOSEPH C. VON HOLLE, LTCOL, USAF
CHIEF, COCKPIT INTEGRATION DIVISION
WRIGHT LABORATORY

If your address has changed, if you wish to be removed from our mailing list, or if the addressee is no longer employed by your organization, please notify Wright Laboratory; Flight Dynamics Directorate; WL/FIPA Bldg 146; 2210 Eighth Street Ste 1; Wright-Patterson Air Force Base, OH 45433-7511 USA

Copies of this report should not be returned unless return is required by security considerations, contractual obligations, or notice on a specific document.

REPORT DOCUMENTATION PAGE

Form Approved
OMB No. 0704-0188

1. AGENCY USE ONLY *(Leave blank)*	2. REPORT DATE	3. REPORT TYPE AND DATES COVERED
	31 OCT 94	Final (4/01/93 -- 5/11/94)

4. TITLE AND SUBTITLE
INTEGRATED MISSION PRECISION ATTACK COCKPIT TECHNOLOGY (IMPACT) PHASE I: IDENTIFYING TECHNOLOGIES FOR AIR-TO-GROUND FIGHTER INTEGRATION

5. FUNDING NUMBERS
F33615-93-D-3800
PE 62201
PR 2403
WU 04
TA SP

6. AUTHOR(S)
Anthony J. Montecalvo, Mark C. Redden, Evan P. Rolek, Horace A. Orr, Gregory J. Barbato

7. PERFORMING ORGANIZATION NAME(S) AND ADDRESS(ES)
Veda, Incorporated
5200 Springfield Pike, Suite 200
Dayton, OH 45431-1255

8. PERFORMING ORGANIZATION REPORT NUMBER

9. SPONSORING / MONITORING AGENCY NAME(S) AND ADDRESS(ES)
FLIGHT DYNAMICS DIRECTORATE
WRIGHT LABORATORY
AIR FORCE MATERIEL COMMAND
WRIGHT PATTERSON AFB OH 45433-7562

10. SPONSORING / MONITORING AGENCY REPORT NUMBER
WL-TR-94-3143

11. SUPPLEMENTARY NOTES

12a. DISTRIBUTION / AVAILABILITY STATEMENT
APPROVED FOR PUBLIC RELEASE;
DISTRIBUTION IS UNLIMITED

12b. DISTRIBUTION CODE

13. ABSTRACT *(Maximum 200 words)*
The Integrated Mission Precision Attack Cockpit Technology (IMPACT) Program focuses on the analysis, design, and test of cockpit control and display concepts for a single seat, multi-role fighter performing precision strike missions against mobile and fixed targets, at night and in adverse weather. This report details the results of the first "Role Playing" Exercise. This was an exploratory evaluation assessing: (1) pilot workload associated with an Air Interdiction mission in a single seat fighter; and (2) advanced technologies having the potential to reduce work- load and increase mission effectiveness. Subjective workload measures were collected for a baseline F-15E, conceptual single-seat F-15E, and an Advanced Technology Cockpit (ATC) using the Subjective Workload Assessment Technique (SWAT) and Subjective Workload Dominance (SWORD) technique. Advanced technologies, assumed to be in use in the year 2005, and their possible mechanizations, were rated using questionnaires and interviews. This report describes the role playing methodology and the test results.

14. SUBJECT TERMS
Role Playing, Human Factors, Air Interdiction, Advanced Technologies, Workload

15. NUMBER OF PAGES
117

16. PRICE CODE

17. SECURITY CLASSIFICATION OF REPORT	18. SECURITY CLASSIFICATION OF THIS PAGE	19. SECURITY CLASSIFICATION OF ABSTRACT	20. LIMITATION OF ABSTRACT
UNCLASSIFIED	UNCLASSIFIED	UNCLASSIFIED	UL

NSN 7540-01-280-5500

Standard Form 298 (Rev. 2-89)
Prescribed by ANSI Std. Z39-18
298-102

FOREWORD

This technical report documents the results of Phase I of the Integrated Mission Precision Attack Cockpit Technology (IMPACT) program. IMPACT's Phase I consisted of a "role-playing" experiment conducted by the United States Air Force with human factors and documentation support from Veda, Inc. under contract F33615-93-D-3800. Lear Siegler Management Services Corporation (LSMSC) provided hardware fabrication and maintenance services under contract F33601-93-D-J019. Both contracts are monitored by Mr. George Palmer of the Wright Laboratory Cockpit Integration Division (WL/FIP). The IMPACT program manager is Mr. Gregory Barbato (WL/FIP).

The following individuals were instrumental to the successful completion of this work.

Software development:	Capt Christopher Brooks, WL/FIP SrA Michael McFarren, WL/FIP Mr. John Hasting, WL/FIP
Hardware fabrication:	Mr. Samuel Longo, LSMSC Mr. Duane Warner, LSMSC
Technical assistance:	Ms. Tammy Brown, Veda, Inc. Mr. Daniel Schornak, LSMSC
Administrative support:	Ms. Renee Spires, Veda, Inc.

The authors also wish to thank the evaluation pilots for the time and effort they spent participating in the experiment and for their suggestions, comments and recommendations.

TABLE OF CONTENTS

LIST OF FIGURES

LIST OF TABLES

LIST OF SYMBOLS, ACRONYMS AND ABBREVIATIONS

ACC	Air Combat Command
AFB	Air Force Base
AGL	Above Ground Level
AIM	Air Intercept Missile
AMRAAM	Advanced Medium Range Air-to-Air Missile
ANOVA	Analysis Of Variance
ATC	Advanced Technology Cockpit
BAI	Battlefield Air Interdiction
CAS	Close Air Support
CSIL	Crew Systems Integration Laboratory
DCA	Defensive Counter Air
FLIR	Forward Looking InfraRed
GBU	Guided Bomb Unit
HDD	Head Down Display
HMDS	Helmet Mounted Display and Sight
MAP	Mission Area Plans
HOTAS	Hands On Throttle And Stick
HRS	Hours
HSS	Head Steered Sensor
IFF	Identify Friend or Foe
IR	InfraRed
JSTARS	Joint Surveillance and Target Attack Radar System
kts	Knots
LANTIRN	Low Altitude Navigation and Targeting InfraRed for Night
LGB	Laser Guided Bomb
LLLTV	Low Level Light TeleVision
MCS	Manned Combat Station
MPCD	Multi-Purpose Color Display
MPD	Multi-Purpose Display
OCA	Offensive Counter Air
OSS	Operations Support Squadron
PROSWAT	Projective Subjective Workload Assessment Technique
PVI	Pilot Vehicle Interface
RMS	Root Mean Square
SA	Situational Awareness
SAM	Surface to Air Missile
SEAD	Suppression of Enemy Air Defenses
TACAN	Tactical Air Navigation
TF	Terrain Following
TSD	Tactical Situation Display
UFC	Up-Front Control
WL/FIP	Wright Laboratory/Cockpit Integration Division
WSO	Weapon Systems Officer

EXECUTIVE SUMMARY

The Cockpit Integration Division of Wright Laboratory, Wright-Patterson AFB, is exploring Pilot Vehicle Interface (PVI) requirements for a single seat fighter performing precision strike missions against multiple mobile and fixed targets, at night and in adverse weather. Such a mission has the potential for dramatically increasing pilot workload and compromising mission effectiveness. To address these issues, the Integrated Mission/Precision Attack Cockpit Technology (IMPACT) program is applying a structured systems engineering process focusing on the conceptual phase of cockpit development. In this program, advanced technologies will be identified, implemented in a simulator, and assessed. This report details the results of the first "Role Playing" exercise...an initial exploratory evaluation assessing pilot workload associated with an air interdiction mission in a single seat aircraft, and advanced technologies having the potential to reduce workload and improve mission effectiveness.

Results of a mission analysis identified the F-15E dual-seat fighter as the baseline weapon system, and the Air Interdiction mission as the baseline mission. The Ingress, Attack and Egress phases of that mission were studied in detail, for those are the segments with the highest workload. A mission decomposition was developed, and timelines and task analyses were completed. Advanced technologies that could be incorporated into the cockpit to reduce workload and increase situational awareness were identified.

A scenario was developed in which the pilot was re-tasked inflight to attack a Scud missile launcher. Pilots were asked to "play the role" of an F-15E pilot and fly scripted air interdiction missions in the simulator, with and without a Weapon Systems Operator (WSO). They were asked to perform all the functions and tasks normally performed by an F-15E pilot during the ingress, attack and egress phases of a mission. While flying the missions in the simulator, the pilots gave their projected workload estimates at predetermined critical mission events using the PROjective Subjective Workload Assessment Technique (PROSWAT).

At the completion of the simulator missions, the pilots were presented with a briefing of seven advanced cockpit technologies. After the briefing, the pilots read an air interdiction mission narrative in which those technologies were incorporated into a single seat fighter with an Advanced Technology Cockpit (ATC). As they read the scenario, they gave their projected workload estimates as they imagined themselves performing the mission. The pilots then used the Subjective WORkload Dominance (SWORD) technique to compare relative workload of the baseline F-15E, a conceptual single seat F-15E and the ATC cockpit when performing three mission functions (in-flight mission replanning, target acquisition and weapon employment). At the end of the study, the pilots completed questionnaires in which they rated the usefulness of the advanced technologies and several proposed mechanizations. The pilots also rated the test methodology.

Results of the study identified four advanced technologies as most critical in reducing pilot workload and improving mission effectiveness: sensor fusion, data link, helmet mounted display and head steered sensor. Pilot workload in the conceptual single seat F-15E was the highest among the three cockpits. Workload for the Advanced Technology Cockpit was the lowest, being slightly less than the dual seat F-15E. Based on the results, the role playing

methodology's scripted scenario technique was deemed acceptable for identifying high workload phases of a mission, analyzing new technologies, and providing direction for design activities within the conceptual design phase. Utility of the role playing methodology was substantiated. All pilots commented on the relative ease in learning and executing a scripted mission scenario. They felt that it provided a good framework for facilitating their ability to project themselves into a real world environment and make projective workload estimates.

The IMPACT role playing exercise marked the first step in defining the requirements for PVI aspects of a single seat, multi-role fighter aircraft attacking targets at night and in adverse weather. From here, additional analyses, designs and trade studies will be identified and pursued to further refine the detailed IMPACT PVI requirements.

INTRODUCTION

The Wright Laboratory's Cockpit Integration Division (WL/FIP) Integrated Mission/Precision Attack Cockpit Technology (IMPACT) program is a research and development effort whose objective is to analyze, design, develop and test cockpit control and display concepts for a single-seat, multi-role fighter aircraft performing a precision strike mission against multiple mobile and fixed targets, at night and in adverse weather. Several Air Combat Command (ACC) Mission Area Plans (MAP) for 1994 enumerate deficiencies regarding the availability of real time and other critical information in the cockpit for performing certain ACC missions. The Strategic Attack/Air Interdiction and the Close Air Support/Air Interdiction MAPs mention target detection and acquisition as problem areas and suggest that possible cockpit-related technology solutions include helmet mounted display and sight (HMDS) systems, color head down displays, visually-coupled acquisition and targeting systems, "combat information managers for fighters" and automatic target recognition. To address these needs, the IMPACT program is applying a structured systems engineering process focusing on the conceptual phase of cockpit development. This phase encompasses three major program events emphasizing the crew station design: (1) Mission Analysis and Interface Requirements, (2) Preliminary Cockpit Design and Trade Studies, and (3) Systems Requirements Definition.

The IMPACT program is using a building block approach, beginning with a baseline cockpit and mission and progressing to more complex cockpits and missions. During the Mission Analysis and Interface Requirements Definition phase, the F-15E dual-seat fighter was identified as the baseline weapon system against which new design concepts could be tested. Its avionics systems, controls and displays, and functional requirements were defined. In the Role Playing exercise, the pilot workload in a conceptual single seat F-15E and the single seat ATC fighter were compared to the baseline aircraft. The Air Interdiction (AI) mission was chosen as the baseline mission because it is one the F-15E currently performs well and has phases of high workload. Other missions reflecting the breadth of multi-role fighter requirements (which are also of importance to the IMPACT program) are Close Air Support (CAS), Battlefield Air Interdiction (BAI), Suppression of Enemy Air Defenses (SEAD), Defensive Counter Air (DCA) and Offensive Counter Air (OCA). The ingress, attack and egress phases of the AI mission were studied

in detail, since those are the areas of highest workload. The AI mission scenario was decomposed into the functions and tasks that are performed by the aircrew in the baseline weapon system. Task timelines were also generated to further guide the analysis of new technologies. The mission decomposition and timelines can be found in the IMPACT Mission Analysis Report.

The Role Playing exercise was an integral part of the analysis activities, structured to help the design team focus its research and development through user participation.

The methodology for collecting user input was based on the PROSWAT technique, developed by Reid and associates (1984), and proven effective in predicting potential workload associated with technology forecasting and assessment methodology (Eggleston, 1984). The initial application of this technique was used in evaluating the effectiveness of candidate crew system enhancements in support of the Radar Aided Mission/Aircrew Capability Exploration (RAM/ACE) program. Operational pilots were presented with detailed verbal and graphical scenarios along with a description of the baseline aircraft and the candidate enhancements. The enhancements included navigation aids, new controls and displays, and new automation features. The pilots were then asked to provide ratings for various events within the scenario. A subset of the candidate technologies was later simulated and real-time SWAT ratings, corresponding to the events previously rated using PROSWAT, were obtained during part task evaluations. Results of the data analysis revealed a strong correlation (.75) between the PROSWAT and real-time SWAT ratings (Quinn, Jauer, and Summers, 1982).

The role playing exercise attempted to build on the RAM/ACE methodology in identifying candidate crew station technologies to support research and development in the IMPACT program. The exercise required operational pilots to perform the role of an F-15E pilot, with and without a Weapon System Operator (WSO). The F-15E "without a WSO" was a conceptual idea since such an aircraft does not actually exist. The "conceptual single seat F-15E" was created only for the purposes of this study. While the F-15E can accomplish the air interdiction mission, the notion of a single seat F-15E was created to identify those aspects of the mission that need to be addressed if the mission is to be performed by a single seat fighter with an Advanced Technology Cockpit. The pilot was also provided with a description of advanced technology candidates, along with their operational benefits, expected to be available in the year 2005.

The design team will use the results of this exercise to support the design, development, and evaluation requirements of a simulated IMPACT cockpit.

SCENARIO

The scenario used in the role playing exercise was a mission typical of those flown by F-15E aircrews during the Gulf War. It contains PVI challenges (such as inflight mission replanning and target acquisition) that will be addressed in the IMPACT program:

The scenario was an air interdiction mission in which the target description and location were passed to the aircrew inflight, with no pre-mission planning or target study accomplished. The air interdiction mission was selected as a starting point because it is a mission the F-15E currently performs well.

Retasking the aircrew inflight to attack a target different than the one originally planned was added to the scenario to increase mission complexity and workload. The target was a Scud missile launcher, observed 10 minutes prior to aircrew receipt of the message, on a major bridge running north/south over a dry river. A Joint Surveillance and Target Attack Radar System (JSTARS) command and control aircraft relayed the bridge coordinates, two low level route points, an egress point and a threat update to the aircrew. The objective was to find and destroy the Scud missile transporter/erector/launcher, which is an eight wheeled vehicle resembling a semi tractor-trailer. Usual support vehicles include a meteorological unit, a tanker and a command and control vehicle. The launcher and support vehicles typically drive off the main roads to set up and launch missiles. The aircraft was configured as follows:

a. Two GBU-10 Laser Guided Bombs (LGBs)
b. Two AIM-120 AMRAAM Medium Range Air to Air Missiles
c. Two AIM-9M Sidewinder Short Range (IR) Air to Air Missiles
d. Conformal fuel tanks
e. LANTIRN Navigation Pod
f. LANTIRN Targeting Pod

An enemy airfield was located 100 NM northwest of the bridge. Additionally, surface to air missiles (SAM) were located 30 NM east and 40 NM north of the bridge. Anti-aircraft artillery was located at various locations along the road, north and south of the bridge. Finally, small arms and man-portable infra-red (IR) SAMs were located in and around the target area, the bridge, and along the road north and south of the bridge.

Weather forecast for the target area was: Scattered clouds at 5000 feet, with winds out of the west at 15 knots. IR transmissivity was 60%. The terrain was characterized by mostly flat desert and rolling hills, with areas of rocky peaks and valleys. The highest peaks were 2000 feet above ground level.

OBJECTIVES

The role playing exercise was conducted to satisfy the following objectives:

1. Identify pilot workload associated with an Air Interdiction mission at night / in adverse weather. Specifically, use SWAT and SWORD to identify the pilot workload for the baseline dual seat F-15E, a conceptual single seat F-15E (no WSO), and a conceptual single seat Advanced Technology Cockpit configuration during the ingress, attack, and egress segments of an air interdiction mission.

2. Identify possible cockpit related technologies that could improve the overall effectiveness of a single-seat fighter performing an interdiction mission at night / in adverse weather. In addition, identify possible control, display and automation candidates necessary for a single seat IMPACT cockpit performing the air interdiction mission.

3. Verify the test methodology. This includes the use of a scripted, pre-planned mission scenario to make projective workload estimates, the utility of SWAT and SWORD in assessing workload and making comparative assessments, and the use of questionnaires and interviews to assess advanced technologies and their mechanizations.

METHOD

Subjects

Four active duty US Air Force fighter pilots participated in the role-playing exercise. The pilots had operational experience with the Low Altitude Navigation and Targeting Infra Red for Night (LANTIRN) system and employment of Laser Guided Bombs (LGB). Two pilots flew the F-16C Block 40 at Hill AFB, UT and two flew the F-15E at Seymour Johnson AFB, NC. The test subject biographical data are shown in Table 1.

Apparatus

The test apparatus used in the role-playing exercise consisted of the following: (1) A simulated F-15E front cockpit, (2) The experimenter's station, (3) Mission checklists and (4) The ATC scenario.

(1) F-15E front cockpit. The evaluation was conducted in the Crew System Integration Laboratory's (CSIL) Manned Combat Station (MCS), configured to represent the front cockpit of the F-15E. The MCS was an F-16 cockpit shell configured with an F-16 sidestick (instead of a center-mounted F-15E stick). For the purposes of this study, switches normally located in the F-15E aft cockpit were moved to the front cockpit.

The simulator provided the pilot a means to "fly" using the stick and throttle, with real time interactive Head-Up Display (HUD) symbology and an outdoor scene available at all times on a Mitsubishi Diamond Scan 16 inch color monitor. The simulator used an F-16 aerodynamic model, driven by an Iris

Table 1. Test Subject Biographical Data

SUBJ #	GRADE	AGE	ORGANIZATION	AERO RATING	A/C FLOWN	HRS	SPECIAL QUALIFICATIONS	DESERT STORM ?
1	O-3	35	388 OSS/OST Hill AFB, UT DSN 458-2017	IP	F-16C F-16A F-4E	1400 100 500	Fighter Weapons Instructor Course LANTIRN Tactics Development	Yes
2	O-3	26	421 FS Hill AFB, UT DSN 458-2636	Pilot	F-16C	875		No
3	O-3	31	336 FS Seymour Johnson AFB, NC DSN 488-6113	Pilot	F-15E F-111D	600 1430	F-15E Functional Check Flight Pilot F-111 RTU IP	No
4	O-3	27	334 FS Seymour Johnson AFB, NC DSN 488-5654	Pilot	F-15E	780		No

4D/220 GTX system updated at 30 Hz. The HUD symbology consisted of a flight path marker, pitch ladder, and heading, altitude and airspeed scales. The distance and time to go to the next steerpoint was displayed in the lower right corner of the display, and the current g and Mach number were displayed in the lower left corner.

The Head Down Display (HDD), consisting of a single Matsushita 27 inch color monitor, presented the pilot with static, non-interactive F-15E cockpit displays (frames). Each frame consisted of the F-15E Up-Front Control (UFC), left Multi- Purpose Display (MPD), center Multi-Purpose Color Display (MPCD) and right MPD (Figure 1). The frames were developed using Designer software and displayed using an Onyx Reality Engine 2 system. The frames were pre-programmed to be synchronized with the checklists and scripts, and were sequenced by the experimenter. The MCS cockpit stick and throttle switches didn't control the HDD, thus the pilots were required to verbalize their HOTAS actions as they performed them.

(2) Experimenter's station. The experimenter's station consisted of a Silicon Graphics keyboard and 19" color monitor positioned adjacent to the MCS cockpit (Figure 2). The experimenter had control over the starting, freezing and restarting of the simulator throughout the tests via a control panel displayed on the monitor. He directly controlled the HDD slides, sequencing them in order based upon the script, the route and the pilot's actions.

(3) Mission checklists. Mission checklists (Appendix A) were used by the pilots during the simulator exercises. These checklists provided a means for the pilots to quickly learn each scenario sequence and follow the scenario in step-by-step fashion.

(4) ATC Scenario. The ATC Scenario consisted of an advanced technology briefing and an ATC narrative. Each pilot received a briefing presenting year 2005 time-frame technology candidates relevant to a multi-role single seat fighter with night and adverse weather combat capability. These technologies, identified in a previous effort within the IMPACT program, were briefed in detail to each pilot and consisted of:

Helmet Mounted Display (HMD)
3-D Audio
Speech Recognition
Sensor Fusion
Data Link
Pilot's Associate (PA)
Head Steered Sensor (HSS)

The ATC narrative (Appendix B) is a "futuristic" scenario in which the seven advanced technology candidates have been incorporated into a single seat fighter. The narrative is a detailed account of an air interdiction mission, describing how the pilot interfaces with the technologies as he flies the mission. After receiving the advanced technology briefing, the pilots read the ATC narrative and gave their projected workload (PROSWAT) ratings for the same mission critical events as in the simulator trials.

Experimental Design

Two independent variables were manipulated during the experiment: Cockpit Configuration and Mission Task. There were three Cockpit Configurations: F-15E dual seat, F-15E single seat and ATC. The notion of a "single seat F-15E" was created to identify those high workload aspects of the mission that must be addressed for it to successfully be performed by a single seat advanced technology fighter. There were

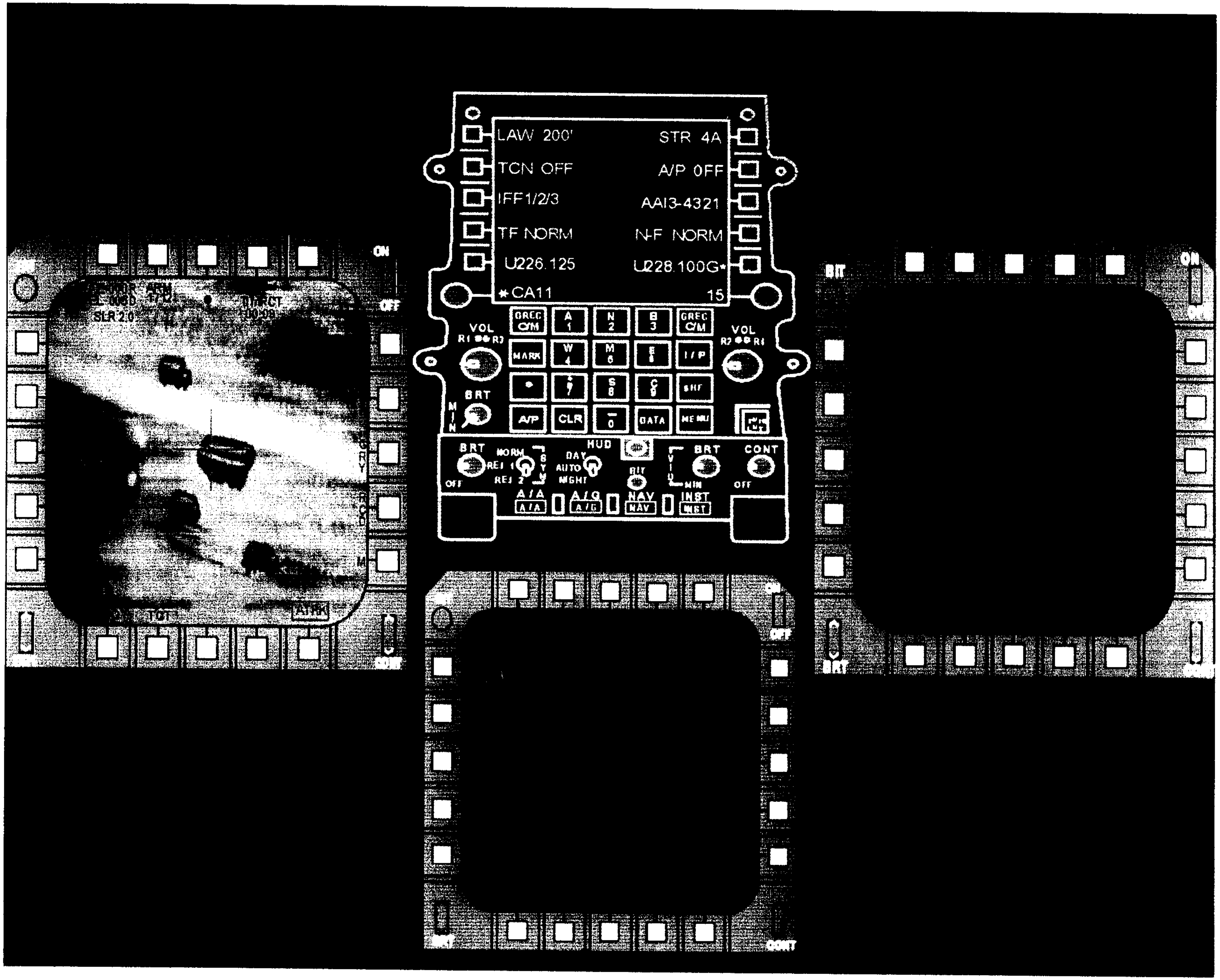

Figure 1. Head Down Display (HDD) Frame Showing F-15E Upfront Control (UFC) and Three Multi Purpose Displays (MPDs)

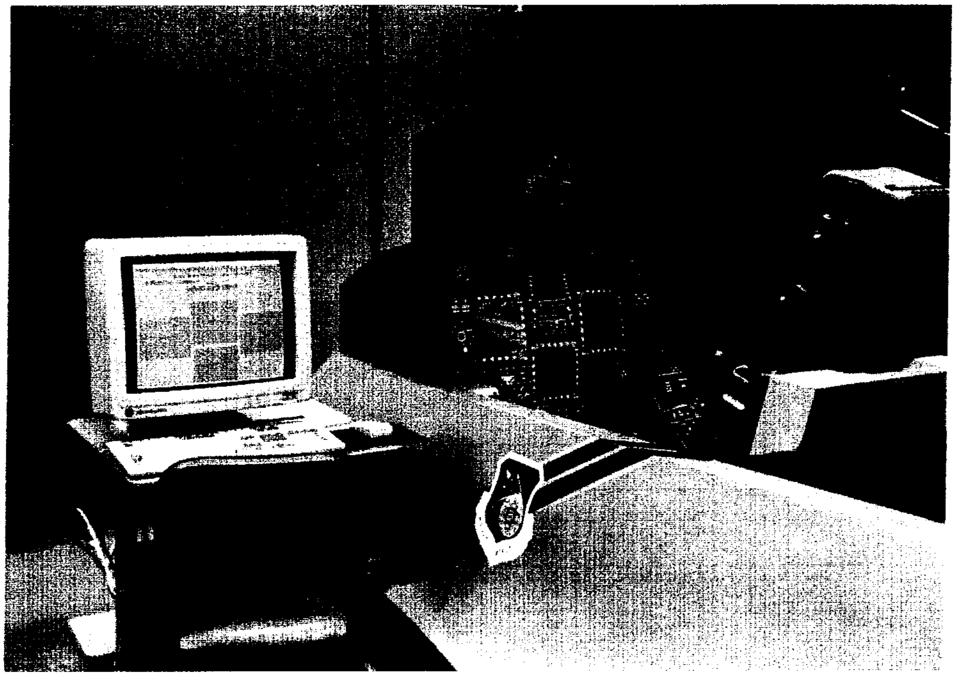

Figure 2. Experimenter's Station (left) and Manned Combat Station (right)

three Mission Tasks: Flying Only Task, in which the pilot flew the mission route using only the HUD; Head Down Task, in which the pilot "stepped through" the mission and performed the required tasks by using only the head down displays; and Dual Task, in which the pilot was required to both fly the simulator and manipulate the HDD frames to complete the mission. The mission tasks provided the necessary diagnosticity to measure pilot performance, and workload for the cockpit tasks, independently and combined. This was a significant aid in identifying areas where the IMPACT team could focus its design activities.

The combinations of cockpit configuration and mission task yielded the Experimental Treatments shown in Table 2. The six experimental treatments were administered to all pilots. The treatments were formed as a subset from a 3 x 3 x 5 repeated measures experimental design. The design was based upon "3" cockpit configurations, "3" tasks, and "5" mission events (input mission change, engage ground threat, obtain patch map, weapon delivery, and engage air threat). The design was a partial factorial design: particular treatment subsets were not administered because meaningful data would not be obtained. Specifically, collecting flying only data for the single seat cockpit, and the ATC cockpit would have

Table 2. Experimental Treatments

		Mission Tasks		
		Flying Only Task	Head Down Task	Dual Task
Cockpits	F-15E dual seat	1	2	3
	F-15E single seat		4	5
	ATC			6

been inefficient since there was no basis to believe that the data would have differed among the three treatments. Also, there was no ATC point design for the pilots to evaluate, so it made little sense to break out the treatments for ATC into flying only, head down only and dual task. As a result, only the dual task treatment was administered for the ATC condition, which required pilots to project their workload as if they were flying the aircraft and performing head down tasks. Subsets of the total experimental design, for purposes of data analysis and interpretation, are further defined in the Results section of this report.

The experimental design developed for this study is shown in Table 3. The use of rated pilots minimized the need for extensive familiarization and training and also afforded credibility to the findings. A small number of replications was adequate for obtaining stable estimates of central tendency (i.e. means) for the experimental treatments since (1) rated pilots were used as subjects and (2) the level of simulation interactiveness had only a fraction of the variability actually encountered in the operational environment.

The experimental design enhanced the probability of successful data collection by minimizing adverse consequences of premature termination of the experiment due to unexpected subject loss, hardware malfunctions, etc. For example, treatments 1 through 5 were administered within each session to ensure that an equal amount of data would be collected for these treatments.

Progressive effects were also considered when developing the experimental design. Fatigue was not a significant factor due to the nature of the experimental tasks and the duration of pilot participation. It was determined that some form of counterbalancing should be implemented to counter potential practice effects. This was favored over a randomization scheme since the limited number of pilots and replications could result in a biased sequence. The counterbalancing was devised so that the dual seat F-15E treatments (2 and 3) and single seat F-15E treatments (4 and 5) always appeared in succession. This would minimize frequent, potentially confusing, shifts of mental perspective between dual seat and single seat cockpits.

The easiest treatment (treatment 1, flying only) was always administered first in each replication to serve as a familiarization

Table 3. Role-Playing Experimental Design

SUBJECT PILOT	REPLICATION 1					REPLICATION 2					REPLICATION 3					ATC SCENARIO
	TRIAL 1	TRIAL 2	TRIAL 3	TRIAL 4	TRIAL 5	1	2	3	4	5	1	2	3	4	5	1
1	TREATMENT 1	TREATMENT 2	TREATMENT 3	TREATMENT 4	TREATMENT 5	1	4	5	2	3	1	2	3	4	5	TREATMENT 6
2	TREATMENT 1	TREATMENT 4	TREATMENT 5	TREATMENT 2	TREATMENT 3	1	2	3	4	5	1	4	5	2	3	TREATMENT 6
3	TREATMENT 1	TREATMENT 2	TREATMENT 3	TREATMENT 4	TREATMENT 5	1	4	5	2	3	1	2	3	4	5	TREATMENT 6
4	TREATMENT 1	TREATMENT 4	TREATMENT 5	TREATMENT 2	TREATMENT 3	1	2	3	4	5	1	4	5	2	3	TREATMENT 6

mission prior to the more difficult treatments. Treatment 6, the ATC scenario, was administered last so that the pilots would have the maximum amount of familiarity with the air interdiction scenario functions. As a result, the pilots would be in the best position to make projective estimates about the needs for and benefits of the various technologies. Treatment 6 was administered only once since there was no reason to believe that reading the ATC mission script more than once would produce any additional data. This treatment was administered in "scripted" form rather than on the simulator to obtain assessments of the concepts, not specific mechanizations.

Procedures

The role-playing exercise was conducted over a two week period, with two pilots participating per week. Each pilot was involved in one day of training and two days of data collection. The first pilot reported to the laboratory on Monday morning, while the second pilot reported Wednesday morning. The first pilot completed the study Wednesday afternoon, and the second pilot finished Friday afternoon.

Training. A training program was developed to familiarize the pilots with their roles and responsibilities during the data collection sessions.

(a) *Ground training.* The ground training program consisted of four hours of briefings and two to four hours of simulator role-playing training. The ground training was divided into two sessions. The first session consisted of administrative items such as facility and safety considerations. The second session consisted of test description, test subject responsibilities, and simulator familiarization. The F-16 pilots spent an additional hour learning the F-15E capabilities, cockpit functionality, and display and control mechanizations (see the IMPACT Mission Analysis and Information Requirements Definition Report).

(b) Data collection training. The data collection training introduced the pilots to the PROSWAT concept. Prior to the exercise, each pilot participated in SWAT training by sorting a set of 27 cards. The sorted cards represent the various dimensions and levels of PROSWAT, from lowest to highest workload. The resulting orderings were subjected to a statistical technique (conjoint measurement technique) to develop a workload scale, from 0 (low workload) to 100 (highest workload), for each pilot. During the simulator training flights, the pilots were asked to report their PROSWAT ratings for practice and familiarization with the technique.

(c) *Flying training.* At the completion of ground and data collection training, each pilot practiced flying the air interdiction mission. A detailed F-15E air interdiction mission narrative (Appendix B), which was read by each pilot prior to the simulator missions, described the required functions, tasks and control switchology necessary to accomplish the mission in the simulator. In this scenario, the pilot was tasked to fly to a contact point, receive a mission change and threat update from a JSTARS aircraft, study the new route and then fly the mission. Input of the mission change consisted of entering the coordinates and elevations of the new low level ingress points, the target, and the egress point. On the route, he was engaged by a SAM. After evading the SAM, he flew up to 1500 feet AGL to make a high resolution patch map of the target area. When complete, he flew back down to low altitude, studied the patch map and attempted to locate the target. At the Initial Point (IP), he turned toward the target, accelerated to 550 knots ground speed and

activated the targeting pod to attempt to visually identify the Scud launcher. He locked onto the target and performed a 10 degree LGB loft, using a delayed lasing technique. After destroying the target, flying the egress maneuver and descending back to low altitude, he used the radar to lock onto an airborne contact. He interrogated the radar contact and determined that it was hostile. When within range, he launched a medium range missile and destroyed the enemy aircraft. A schematic of the simulator mission route is shown in Figure 3.

Each pilot spent the afternoon of day one practicing the 10-minute simulator missions. Each treatment was practiced until the pilot was comfortable with the scenario, could "play the role" according to the mission checklist, and the experimenter was satisfied that the pilot was adequately trained. WSO functions were performed by the experimenter.

Testing. On the second day, the actual simulator testing began. Each pilot flew 15 data collection runs, as described in the Experimental Design section. For each treatment, a practice mission was flown prior to the first data collection run to refresh the pilot's memory. Each mission was flown according to the F-15E Air Interdiction Mission Narrative (Appendix A) and the Mission Checklists (Appendix B). SWAT ratings were collected at the critical mission events, and after each mission for an overall rating, as described in the Data Collection section.

After the last simulator mission, each pilot was interviewed by the IMPACT staff. The pilots were presented their SWAT ratings for each mission and asked what factors were influential in those ratings.

On day three each pilot received the Advanced Technology Briefing. They then read the ATC narrative in which those advanced technologies were incorporated in a single seat fighter aircraft. The pilots completed the SWORD rating form, comparing the relative workload of the three cockpits (F-15E dual seat, F-15E single seat, ATC) and three mission tasks (inflight mission replanning, target acquisition, weapons employment).

The pilots completed two questionnaires to finish the test period. In the first, they rated the advanced technologies and their mechanizations, and in the second they rated the test methodology.

Data Collection

Three types of data were collected: (1) Workload data, (2) Performance data and (3) Questionnaire data. The following sections describe each of these in detail.

(1) Workload Data

(a) PROSWAT - PROSWAT assumes that workload is composed of three dimensions: time stress, mental effort, and psychological stress (Reid, 1989):

- Time Stress refers to the amount of time available to an operator to accomplish a task, and is rated on a 3-point scale ranging from 1 (Often have spare time) to 3 (Almost never have spare time).

- Mental Effort refers to the amount of attention or concentration that is required to perform a task and is rated on a 3-point scale ranging from 1 (Very little conscious effort) to 3 (Excessive mental effort and concentration is required).

- Psychological Stress refers to the presence of confusion, frustration or anxiety associated with a task and is also rated on a3-point scale from 1 (Little confusion, risk, frustration, and/or anxiety exists and can easily be accommodated, to a 3 (High to very

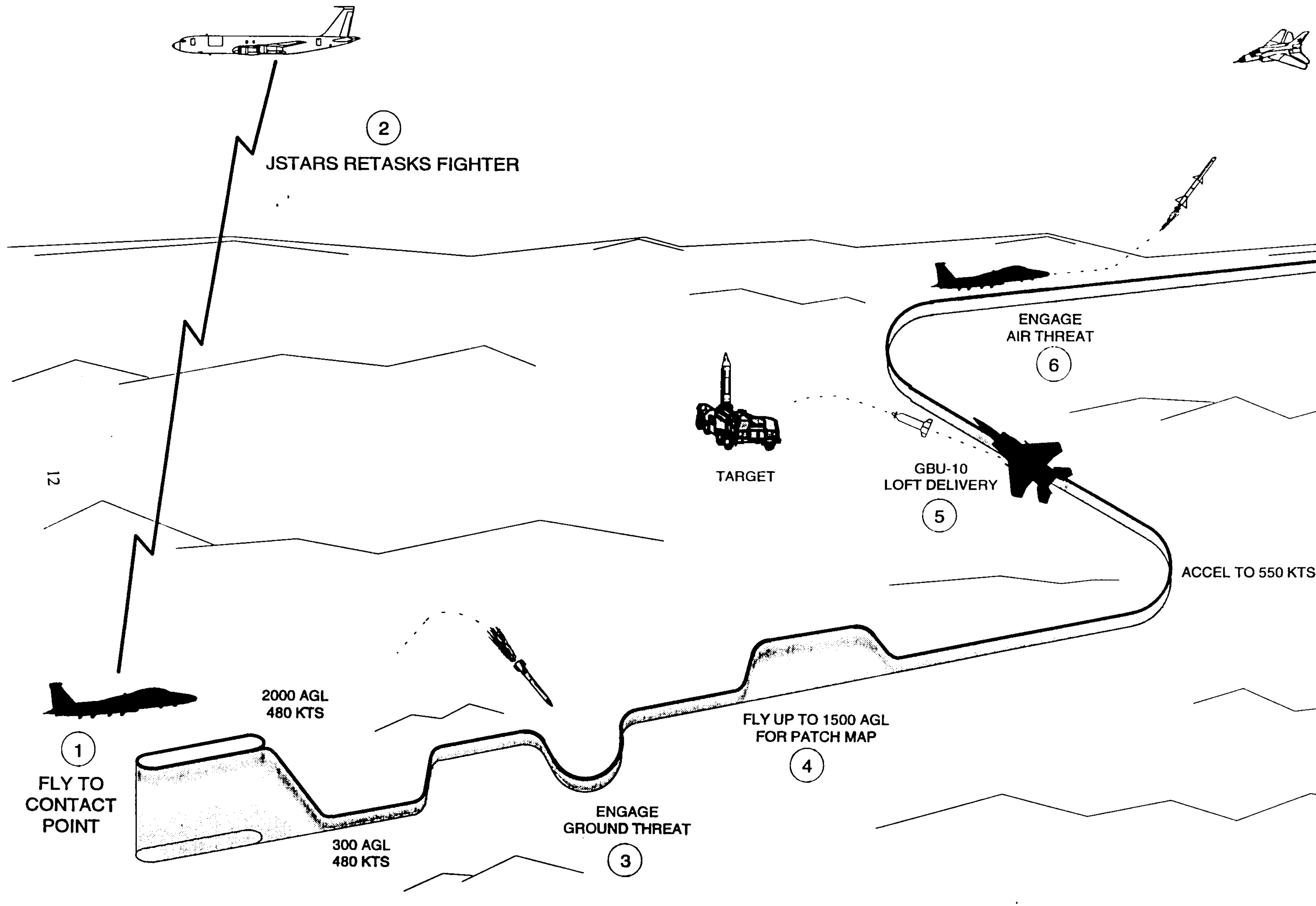

Figure 3. Mission Route Schematic

intense stress due to confusion, frustration, or anxiety).

During the exercise, workload was reported in three separate ratings, one for each dimension. For example, an extremely high workload task would be reported as "3,3,3" for time load, mental effort, and psychological stress, respectively.

PROSWAT ratings were collected for five critical events, and at the completion of each simulator trial for an overall rating, during each air interdiction mission (in the simulator and the ATC narrative). At the completion of all simulator missions, each pilot was shown his PROSWAT ratings and was asked to describe the factors that contributed to those ratings.

(b) SWORD - The SWORD technique was used in the role playing exercise to compare the relative workload of the different cockpit configurations and tasks. These relative judgments were used to generate a rating for each cockpit configuration and task, which were in turn statistically analyzed. After receiving the advanced technology briefing and reading the ATC scenario, the pilots completed a SWORD rating form which provided a comparison between the baseline dual-seat F-15E, the single-seat F-15E, and the ATC configurations, with reference to three primary functions (In-Flight Replanning, Target Acquisition, and Weapons Employment). An example of the SWORD rating form is shown in Figure 4.

(2) Performance Data

The performance data focused on the pilot's ability to maintain a commanded airspeed and altitude, and keep the flight path marker within the HUD manual terrain following (TF) box during the mission. It is recognized that in actual aircraft, pilots would use the AUTO TF mode of the LANTIRN system when flying low altitude, at night / in adverse weather. In the role playing exercise, the pilots were asked to fly the simulator "hands on" (without autopilot) to increase their task loading and stress, better replicating an actual mission. The tracking measures include Root Mean Square (RMS) altitude deviation and RMS airspeed deviation from commanded values, and RMS lateral and vertical deviation from the HUD manual TF box. The pilots were tasked to fly the mission at 480 knots airspeed and 300 feet altitude, except during the Mission Change Input phase (2000 feet altitude), the Obtain Patch Map phase (1500 feet altitude) and the Weapon Delivery phase (550 knots, loft delivery and recovery). Performance data were collected during each simulator mission.

(3) Questionnaire Data. At the end of the test, the pilots were asked to complete two questionnaires: Technology Assessment and Test Methodology (see Appendix D):

(a) Questionnaire I - Technology Assessment (Part I): With reference to the ATC scenario, each technology was rated for its effect on pilot workload and mission effectiveness in the following mission areas:

- Fly the aircraft
- Navigate
- Manage threats
- Acquire targets
- Employ weapons
- Replan the mission inflight
- Situational awareness

(b) Questionnaire I - Technology Assessment (Part II) - Technology Implementation: Various mechanizations of each technology were proposed in the questionnaire, and the pilots were asked if these mechanizations would enhance or

degrade their ability to perform the IMPACT mission.

(c) Test Methodology - The test subjects were asked to rate the simulator, the role-playing methodology and the data collection procedures.

SUBJECT # ______

	>>>> >>> >> > EQUAL < << <<< <<<<	
F15E 2 - REPL	___ ___ ___ ___ ___ ___ ___ ___ |__| ___ ___ ___ ___ ___ ___ ___ ___	F15E2 -TGTA
F15E 2 - REPL	___ ___ ___ ___ ___ ___ ___ ___ |__| ___ ___ ___ ___ ___ ___ ___ ___	F15E2 - WPNE
F15E 2 - REPL	___ ___ ___ ___ ___ ___ ___ ___ |__| ___ ___ ___ ___ ___ ___ ___ ___	F15E1 - REPL
F15E 2 - REPL	___ ___ ___ ___ ___ ___ ___ ___ |__| ___ ___ ___ ___ ___ ___ ___ ___	F15E1 - TGTA
F15E 2 - REPL	___ ___ ___ ___ ___ ___ ___ ___ |__| ___ ___ ___ ___ ___ ___ ___ ___	F15E1 - WPNE
F15E 2 - REPL	___ ___ ___ ___ ___ ___ ___ ___ |__| ___ ___ ___ ___ ___ ___ ___ ___	ATC - REPL
F15E 2 - REPL	___ ___ ___ ___ ___ ___ ___ ___ |__| ___ ___ ___ ___ ___ ___ ___ ___	ATC - TGTA
F15E 2 - REPL	___ ___ ___ ___ ___ ___ ___ ___ |__| ___ ___ ___ ___ ___ ___ ___ ___	ATC - WPNE
F15E2 -TGTA	___ ___ ___ ___ ___ ___ ___ ___ |__| ___ ___ ___ ___ ___ ___ ___ ___	F15E2 - WPNE
F15E2 -TGTA	___ ___ ___ ___ ___ ___ ___ ___ |__| ___ ___ ___ ___ ___ ___ ___ ___	F15E1 - REPL
F15E2 -TGTA	___ ___ ___ ___ ___ ___ ___ ___ |__| ___ ___ ___ ___ ___ ___ ___ ___	F15E1 - TGTA
F15E2 -TGTA	___ ___ ___ ___ ___ ___ ___ ___ |__| ___ ___ ___ ___ ___ ___ ___ ___	F15E1 - WPNE
F15E2 -TGTA	___ ___ ___ ___ ___ ___ ___ ___ |__| ___ ___ ___ ___ ___ ___ ___ ___	ATC - REPL
F15E2 -TGTA	___ ___ ___ ___ ___ ___ ___ ___ |__| ___ ___ ___ ___ ___ ___ ___ ___	ATC - TGTA
F15E2 -TGTA	___ ___ ___ ___ ___ ___ ___ ___ |__| ___ ___ ___ ___ ___ ___ ___ ___	ATC - WPNE

AIRCRAFT:
F15E2 = F-15E DUAL SEAT
F15E1 = F-15E SINGLE SEAT
ATC = ADVANCED TECHNOLOGY COCKPIT

FUNCTIONS:
REPL = INFLIGHT REPLANNING
TGTA = TARGET ACQUISITION
WPNE = WEAPON EMPLOYMENT

Figure 4. Sample SWORD Rating Form

RESULTS

Introduction

Results of the data collection will be presented according to the general order in which the data were collected - SWAT, SWORD, questionnaires, and objective data. Complete data are contained in the appendices. In the interests of brevity, only the most significant findings are presented within this section. Specific subsets of the data will be treated in more detail in the Discussion section. Where appropriate, the results of the statistical analyses are also presented for the respective subsets of the data. Since the purpose of the study was to obtain trend information, the statistical analyses were performed to clarify the trend data rather than being the primary focus of this effort. Aggregation and interpretation of the results are contained in the Discussion section.

SWAT

Results from the SWAT data collection are presented in groups according to (1) findings from the statistical analyses and (2) data plots intended to afford insights into workload trends. A repeated measures mixed effects analysis of variance (ANOVA) was used to analyze the SWAT data. The results of this analysis indicated statistically significant main effects for Treatment, Cockpit, and Event. However, there was a statistically significant interaction, between Cockpit type and mission Event; hence, the interaction between Cockpit and Event will be interpreted prior to the interpretation of Cockpit and Event as main effects.

Figure 5 summarizes the results of the SWAT ratings for overall mission workload as a function of the six treatment conditions. The associated ANOVA summary table is shown in Table 4. In terms of overall mission workload, determining if there were any differences among the dual task main effects (i.e., dual task F-15E dual seat, dual task F-15E single seat, and dual task ATC) was of primary interest. Duncans's range test was used to carry out pairwise comparisons of those main effects and the results are presented in Table 5.

The SWAT ratings for mission Events and Cockpit type are presented in Figure 6. ANOVA summary tables reflecting the statistically significant main effects and interactions are presented in Table 6.

A visual inspection of Figure 6 suggests that the cockpit-by-event interaction effect can be attributed primarily to the overlapping/intersecting plots for Mission Change, Ground Threat, and Weapon Delivery mission events.

The statistical significance of the workload ratings for the mission Event factor can be attributed to the Mission Change and Ground Threat events. The Mission Change event was generally rated as the lowest workload event with all of the means falling below a SWAT rating of 40. This was to be expected, because the pilots were asked their SWAT ratings only for the tasks of inputting the new coordinates and elevations of the new points (via the UFC), and studying the updated route which was displayed on the TSD. The Ground Threat event SWAT means clustered to form the event with the highest workload rating. The means across the remaining events, Obtain Map, Weapon Delivery, and Air Threat, tended to converge toward a SWAT score of 40 or slightly above, not indicative of likely workload problem areas.

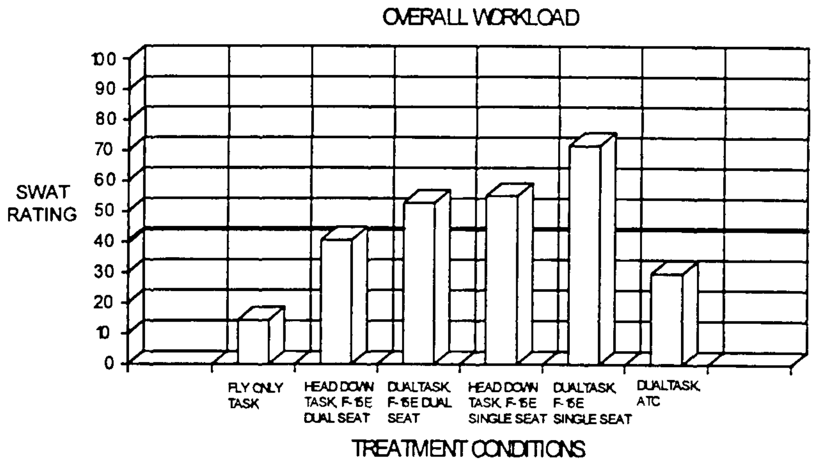

Figure 5. Overall SWAT Ratings for All Treatments

Table 4. ANOVA Summary - Overall SWAT for Treatments

Source of Variation	SS	DF	MS	F	Sig of F
Treatment by Subject	2865.37	15	191.02		
Treatment	8188.29	5	1637.66	8.57	.001

Table 5. Duncan t Summary - Simple Main Comparisons

Treatment of Conditions	df	Sig. of F
Dual task F-15E dual seat vs. Dual task F-15E single seat	15	N.S.
Dual task F-15E dual seat vs Dual task ATC	15	.05
Dual task F-15E single seat vs. Dual task ATC	15	.05

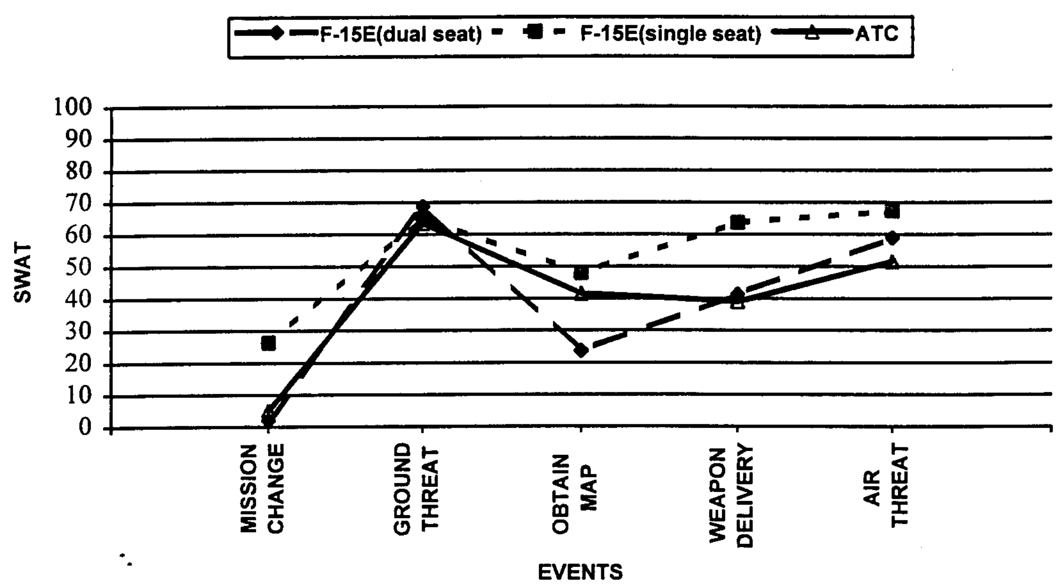

Figure 6. SWAT Comparison, Dual Task

Table 6. ANOVA Summary - SWAT Comparison, Dual Task

Source of Variation	SS	DF	MS	F	Sig of F
Cockpit by Event	1878.03	8	234.75	3.40	.009
Cockpit	2823.52	2	1411.76	4.94	.054
Event	22152.04	4	5538.01	9.36	.001
Cockpit By Event by Subject	1655.17	24	68.97		
Cockpit by Subject	1716.22	6	286.04		
Event by Subject	7099.08	12	591.59		

SWORD

Results of the SWORD ratings are presented in Figure 7, with the results of the ANOVA presented in Table 7. Statistically significant results were obtained for the interaction between Aircraft and Function and the main effect due to Aircraft and Function. Duncan's range test was used to carry out pairwise comparison of the data for the aircraft and function interaction. Across the three functions, no differences were demonstrated between the F-15E dual seat and the ATC cockpits. For the inflight mission replanning function, no differences were demonstrated among the three cockpits ($F[2,6] = 2.72$, $p=.14$). For both target acquisition and weapon employment, the F-15E single seat cockpit demonstrated a significant difference from the other two cockpits (target acquisition: $F[2, 6] = 28.40$, $p = .0009$; weapon employment: $F[2,6] = 9.65$. $p = .013$).

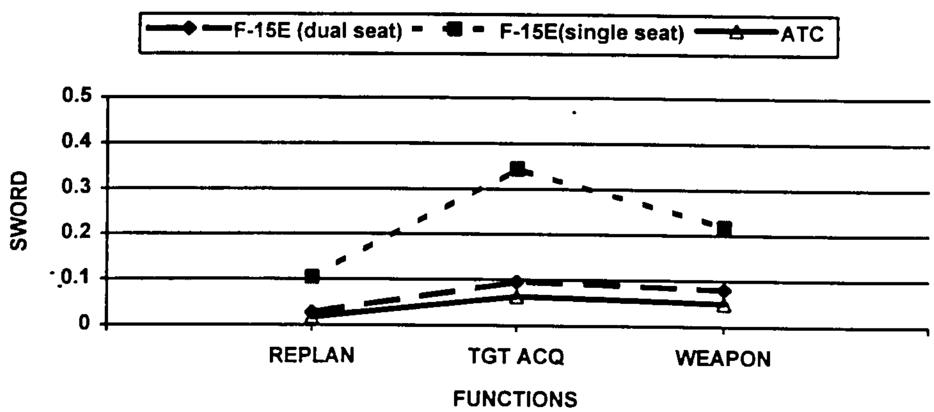

Figure 7. SWORD Results

Table 7. ANOVA Summary - SWORD Results

Source of Variation	SS	DF	MS	F	Sig of F
Aircraft by Function	.05	4	.01	5.87	.007
Aircraft	.23	2	.11	63.76	.000
Function	.08	2	.04	9.18	.015
Aircraft by Function by Subject	.02	12	.00		
Aircraft by Subject	.01	6	.00		
Function by Subject	.03	6	.00		

These SWORD data show that for inflight mission replanning, target acquisition and weapon employment functions, there were no differences between the F-15E dual seat and the ATC cockpits. This finding indicates that the design team was successful in conceptualizing a single seat, ATC cockpit to perform present day, two seat missions and did not significantly increase pilot workload. In addition, the data demonstrate that removing the back seater from the two seat F-15E is not a viable single seat option for performing those same missions -- except for inflight mission replanning, the single seat F-15E has significantly higher SWORD ratings than either of the other two cockpits.

Questionnaires

Due to the length of some of the questionnaires, only the results from the rating scales and certain tabular data will be presented here. Related narrative responses can be found in the appendices. The results will be presented according to technology assessment, and methodology assessment. Additional treatment of these topics can also be found in the discussion section. Emphasis has been given to:

- Mission effectiveness for the proposed technology concepts
- Utility of the proposed technology concepts for various mission phases
- Utility of specific concept mechanizations
- Assessment of the role playing methodology

The results from the rating scales were rearranged and are presented in descending order according to the respective attribute rated. While this presentation does not convey the order in which the scales were administered, it does facilitate the determination of trends. For the interested reader, the exact order of administration can be seen in the appendices. The narrative responses were not disregarded, however, but are treated in the Discussion section.

Part I - Technology Assessment. Figure 8 depicts the ratings of the technology concepts from the perspective of contribution to overall mission effectiveness. This was used as a "first cut" assessment of the technologies. The next set of ratings presented (see Figures 9 through 15) illustrates how the pilots rated the potential enhancement of the various mission phases through implementation of the technology concepts for various mission phases or

functions. Note that the mission phases and functions are not uniform across the technology concepts. This was due to the design of the rating scales that reflected a tailoring of the scale categories according to the appropriateness of the technologies to various mission functions.

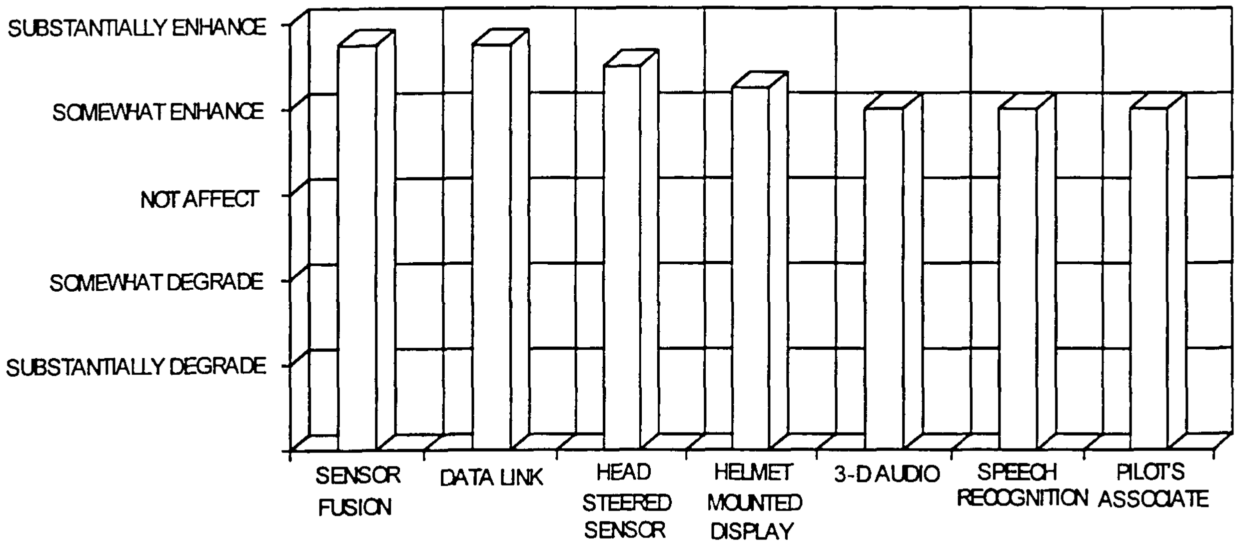

Figure 8. The Effect of Advanced Technologies on Mission Effectiveness

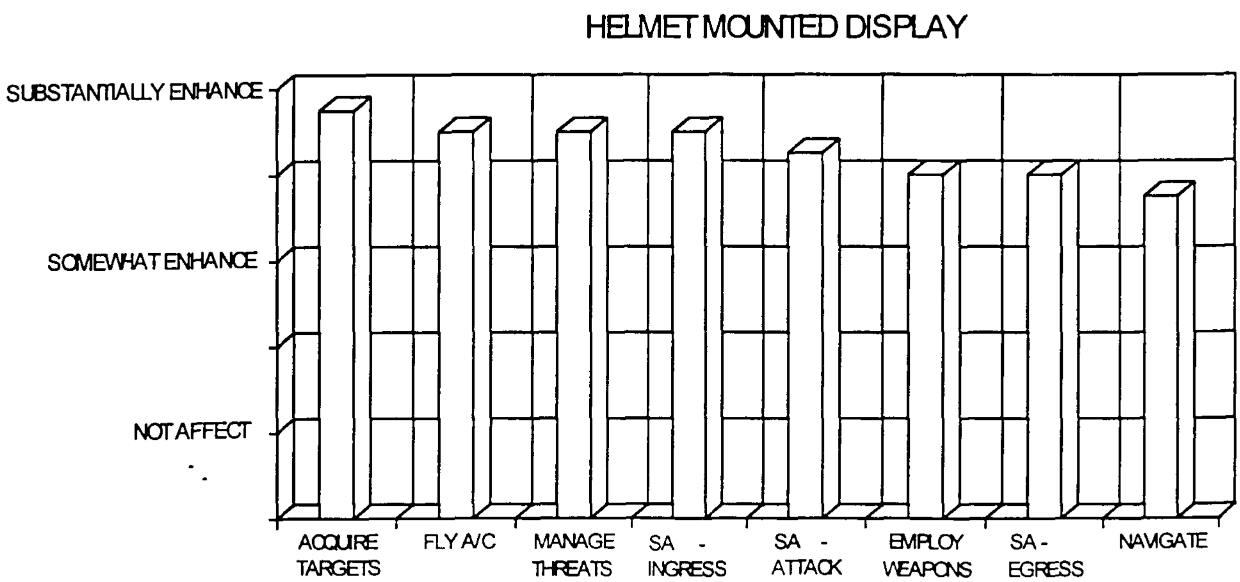

Figure 9. The effect of HMD on Mission Events

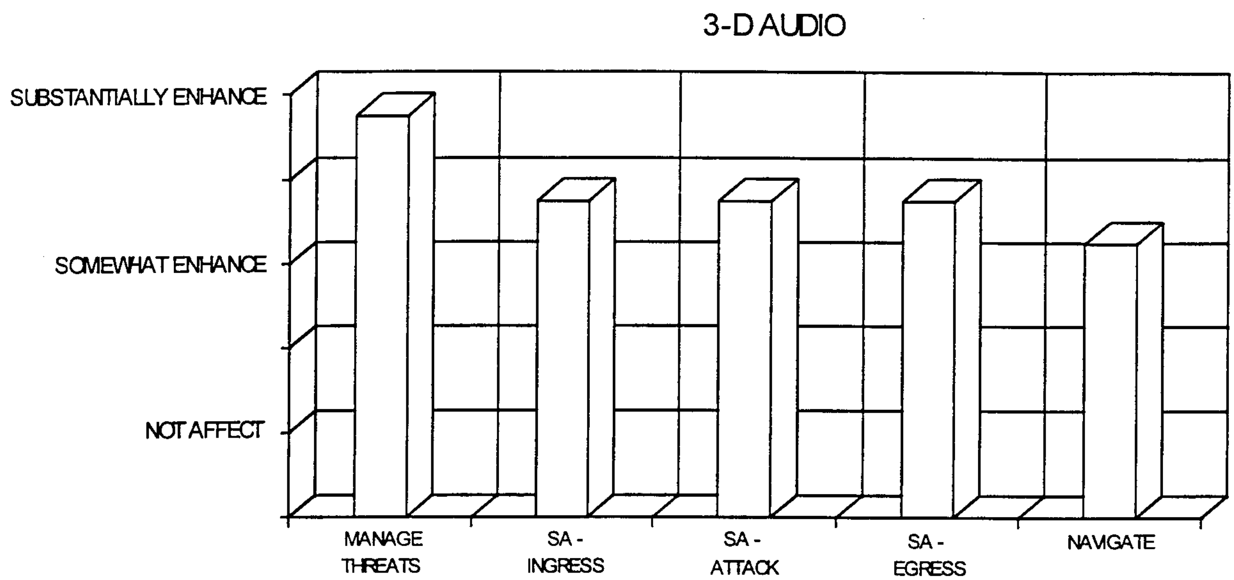

Figure 10. The effect of 3D Audio on Mission Events

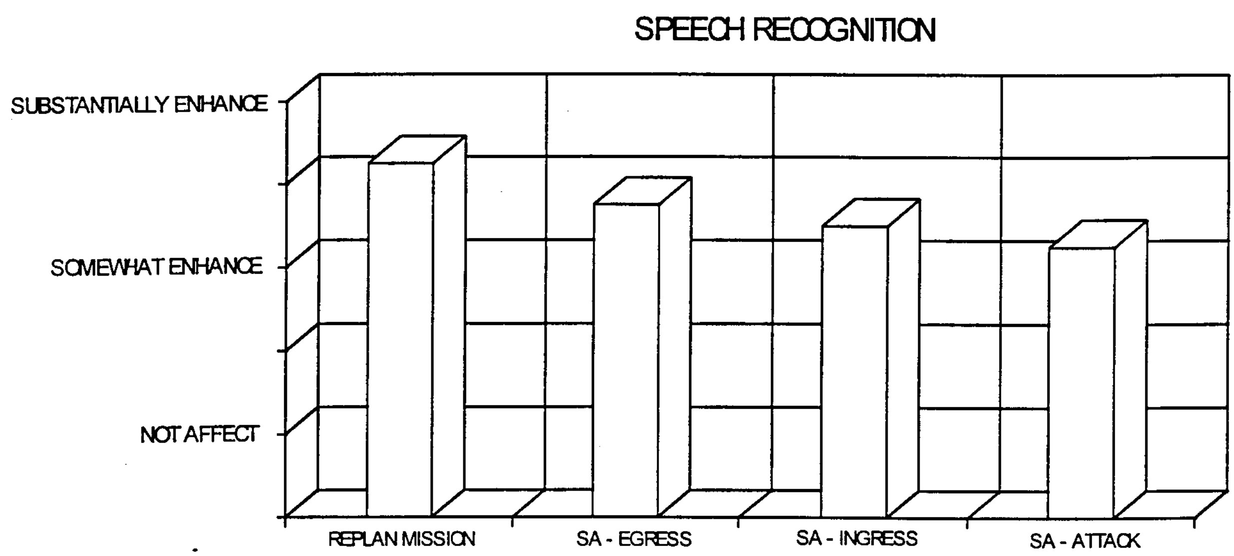

Figure 11. The effect of Speech Recognition on Mission Events

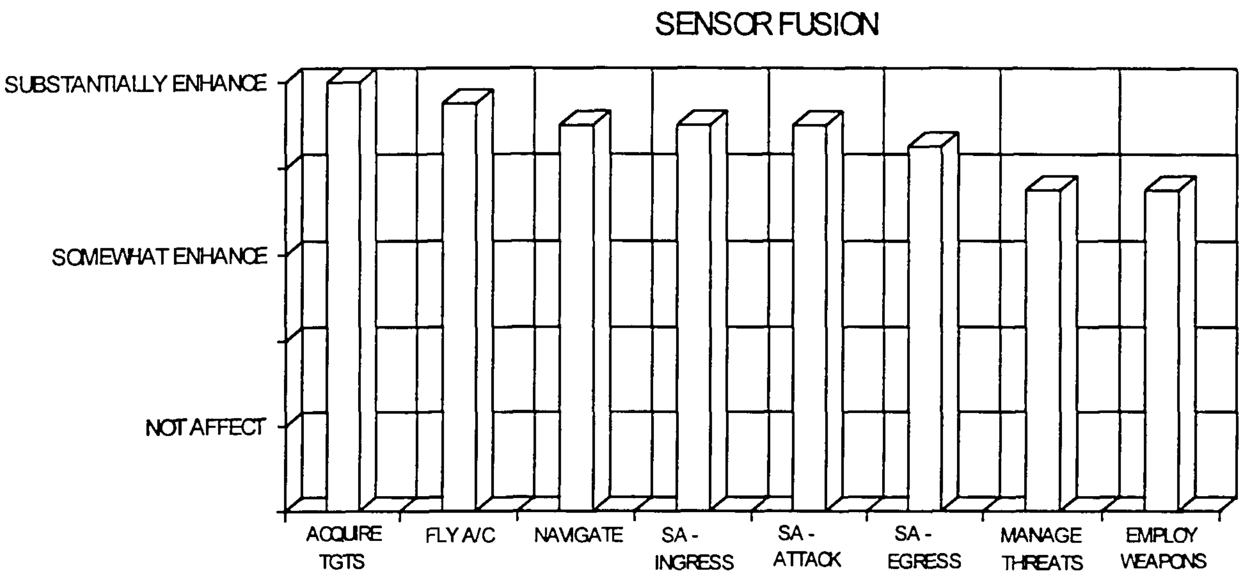

Figure 12. The effect of Sensor Fusion on Mission Events

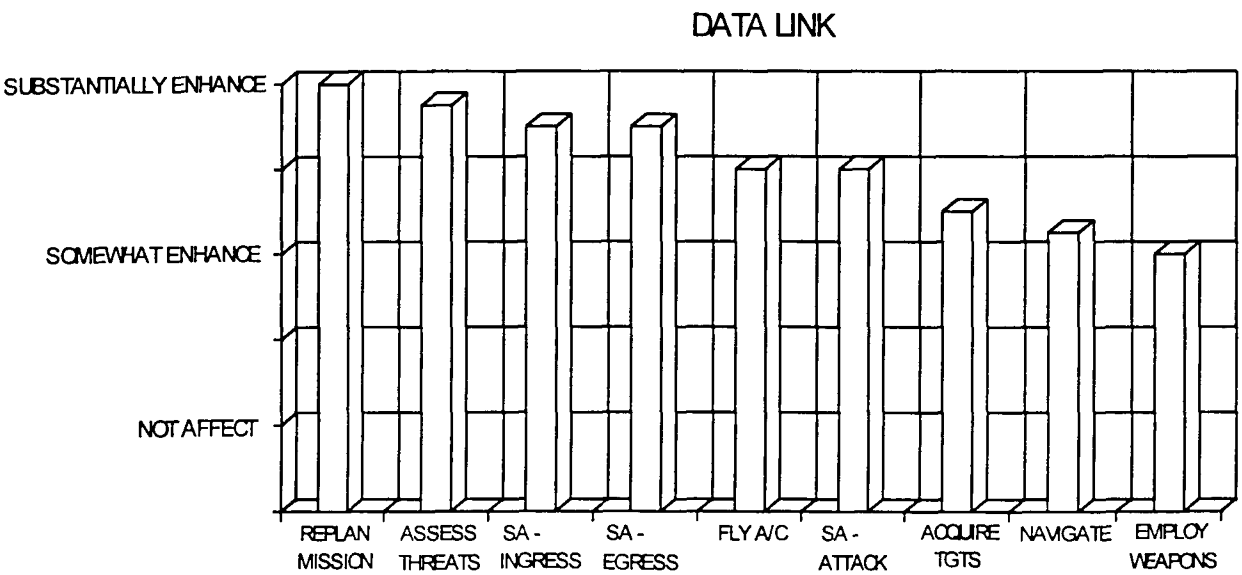

Figure 13. The effect of Data Link on Mission Events

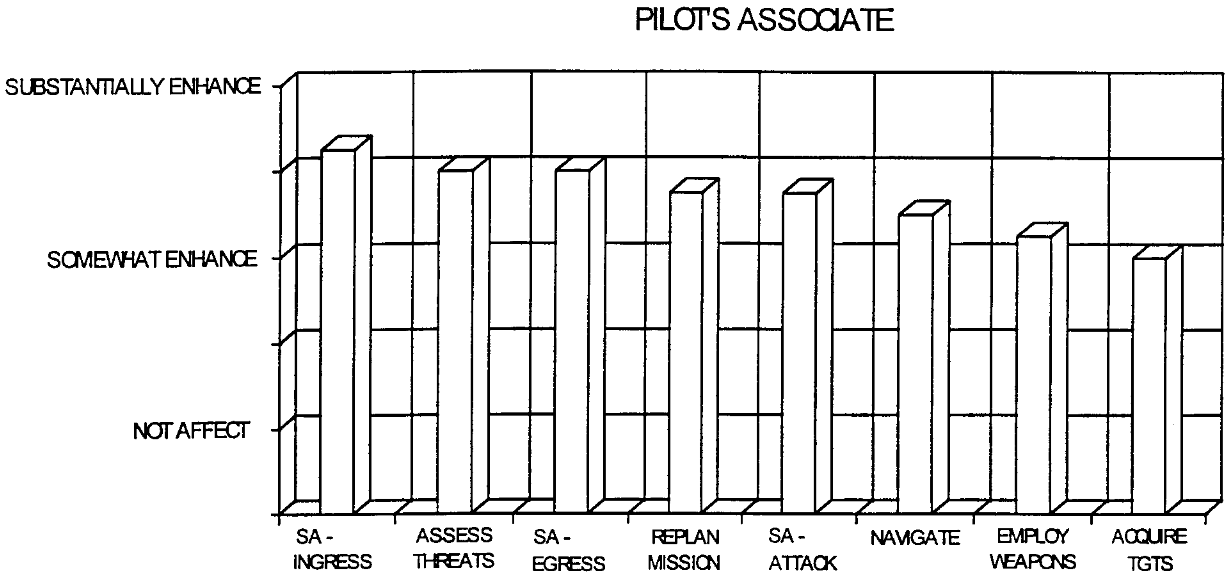

Figure 14. The effect of Pilot's Associate on Mission Events

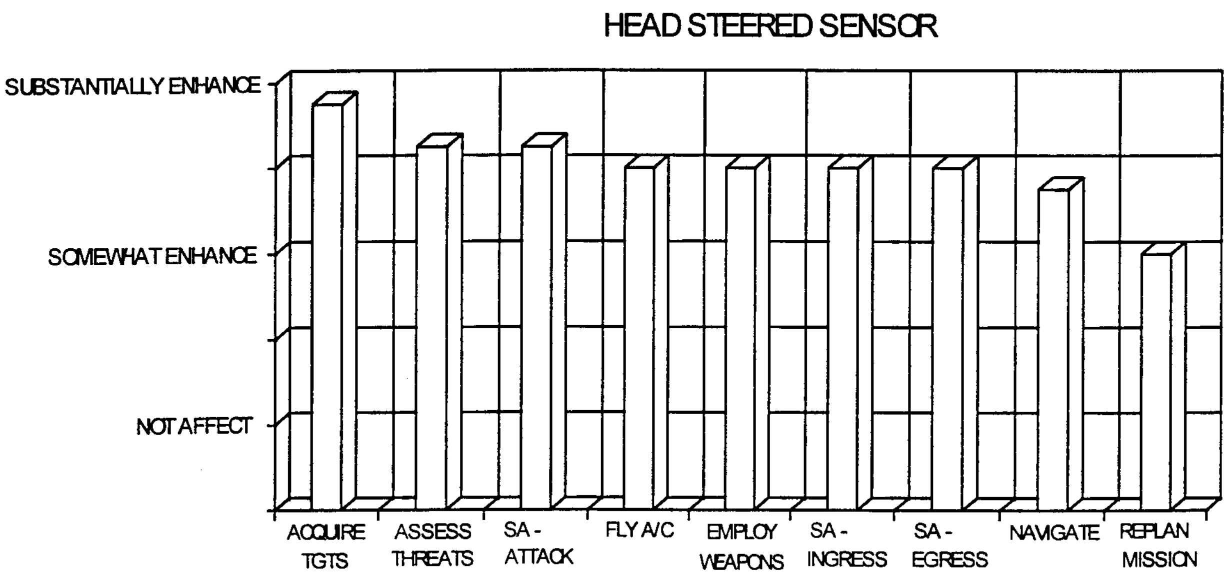

Figure 15. The effect of HSS on Mission Events

Part II - Technology Mechanizations. To obtain an even more refined assessment of the technologies, specific mechanizations were rated according to their projected utility for enhancing the air interdiction mission. These ratings are summarized in Figures 16 through 22.

Role Playing Methodology. The pilots also provided ratings concerning the role playing methodology. Various activities were probed within the study to determine what areas could be improved upon and which should be retained as currently implemented. These ratings did not seek pilots' assessment of the theoretical basis for the study but rather an evaluation of the ease with which the methodology facilitated their ability to provide the technology and workload assessments. The interested reader can find the ratings and narratives in the appendices.

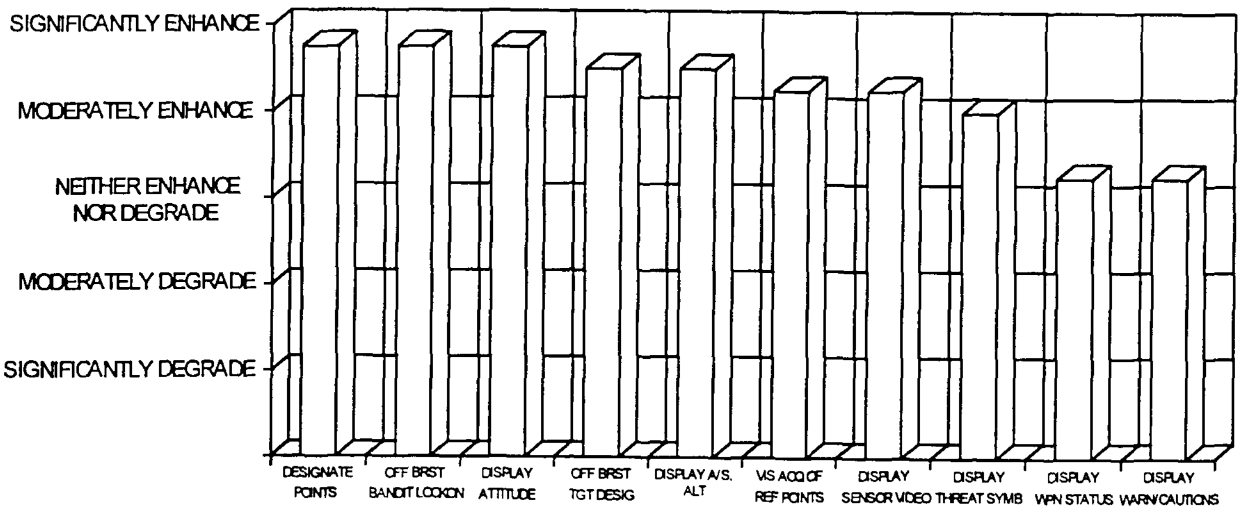

Figure 16. Helmet Mounted Display Mechanizations and Their Effects on Performing the IMPACT Mission

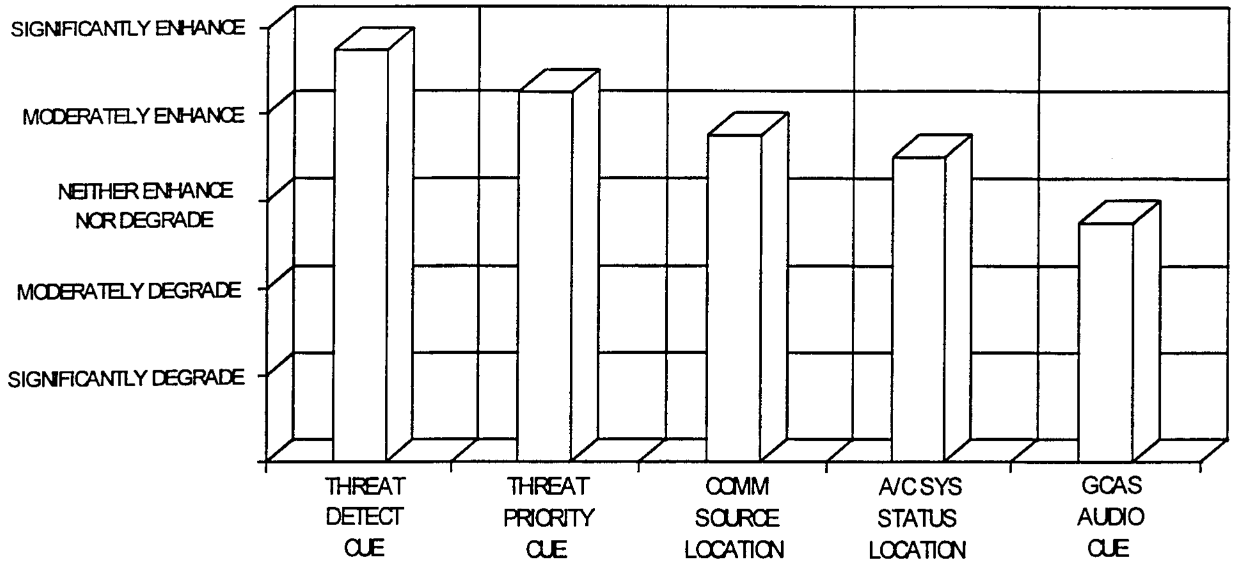

Figure 17. 3-D Audio Mechanizations and Their Effects on Performing the IMPACT Mission

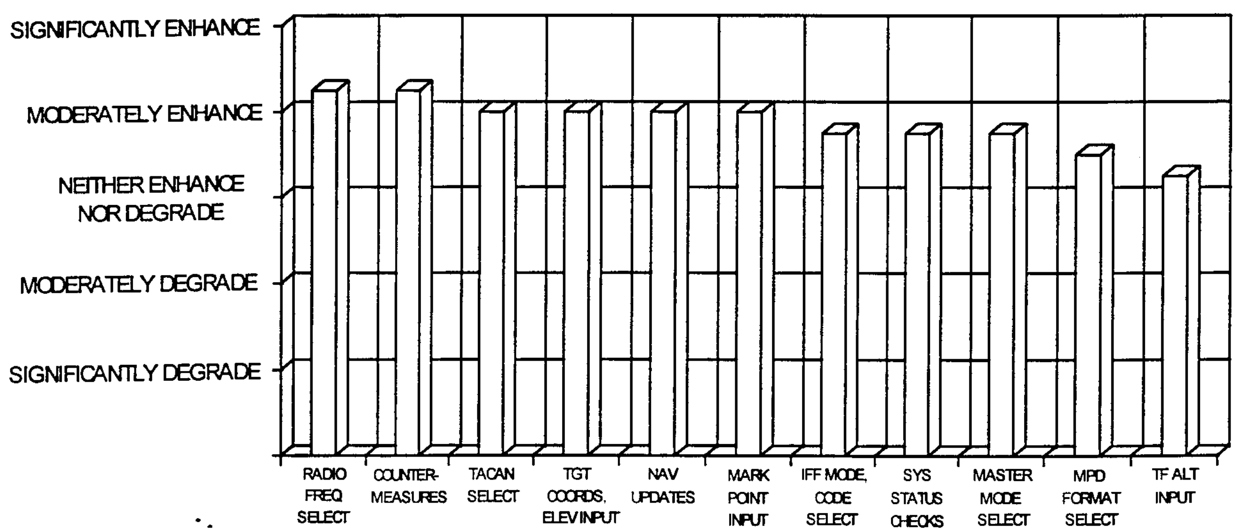

Figure 18. Speech Recognition Mechanizations and Their Effects on Performing the IMPACT Mission

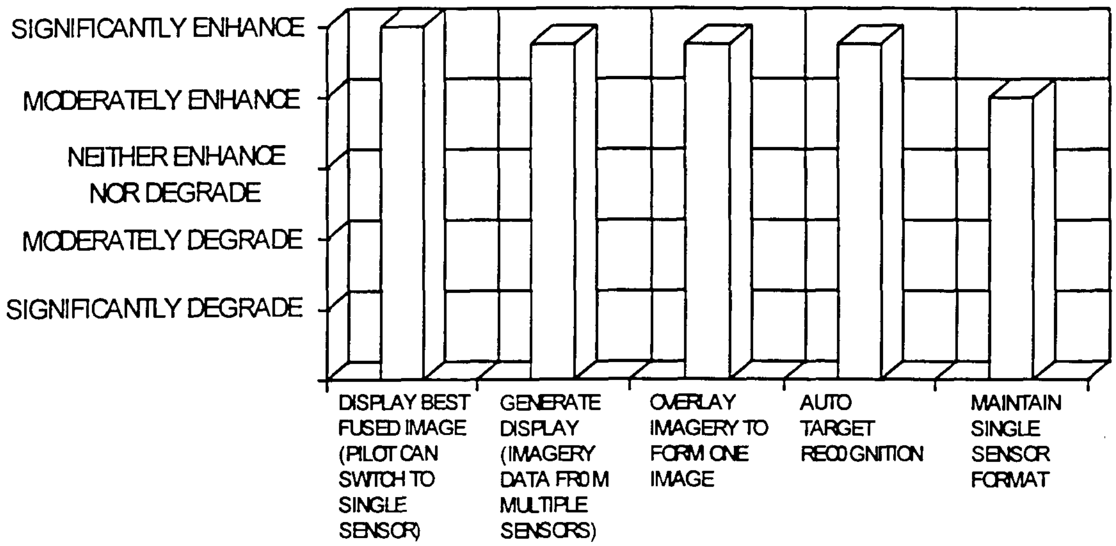

Figure 19. Sensor Fusion Mechanizations and Their Effects on Performing the IMPACT Mission

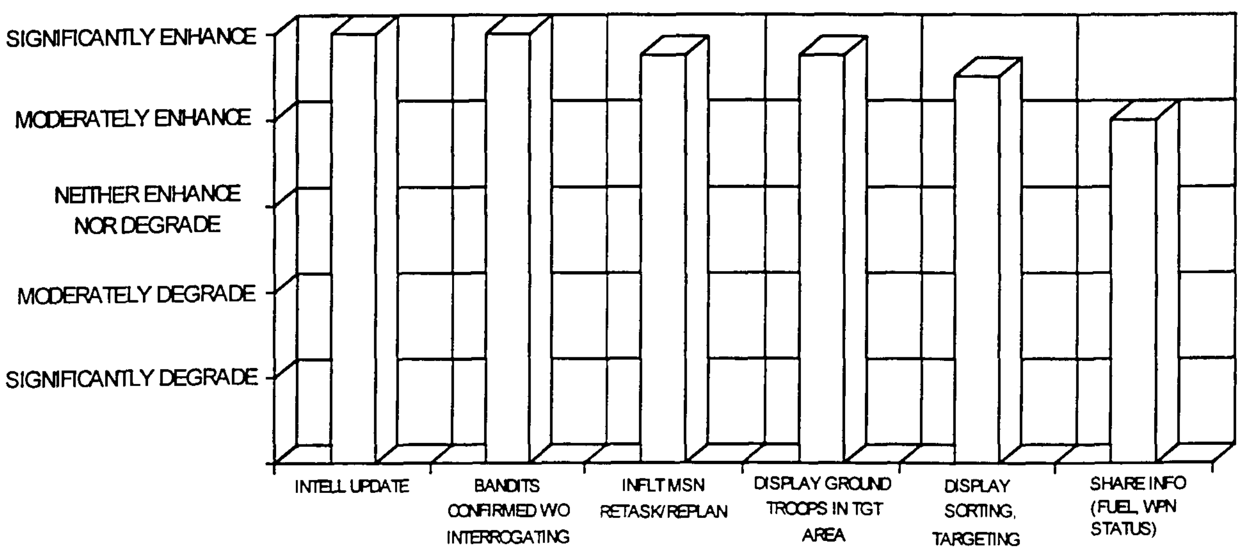

Figure 20. Data Link Mechanizations and Their Effects on Performing the IMPACT Mission

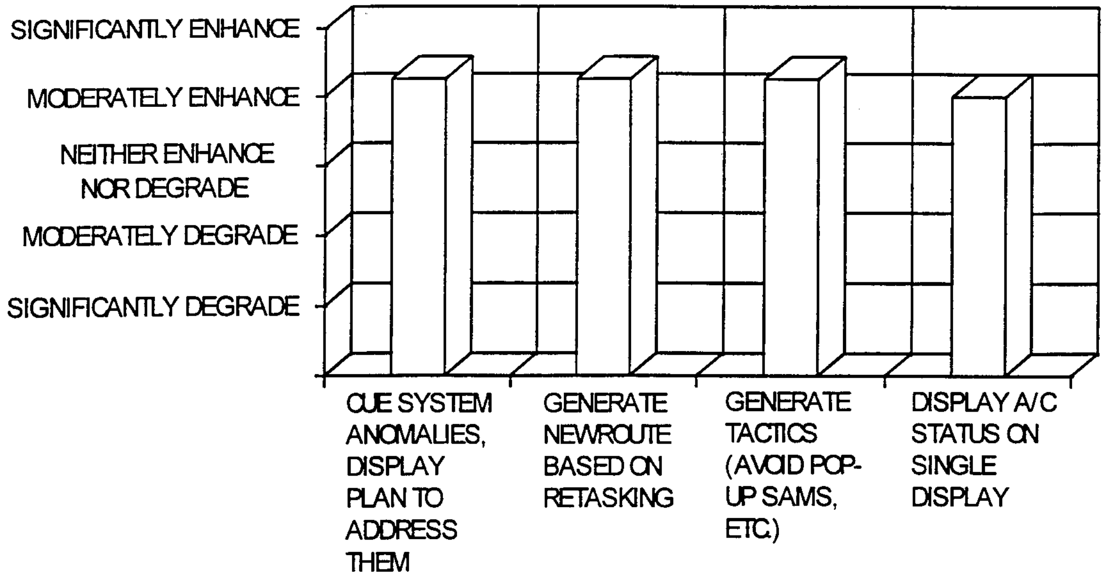

Figure 21. Pilot's Associate Mechanizations and Their Effects on Performing the IMPACT Mission

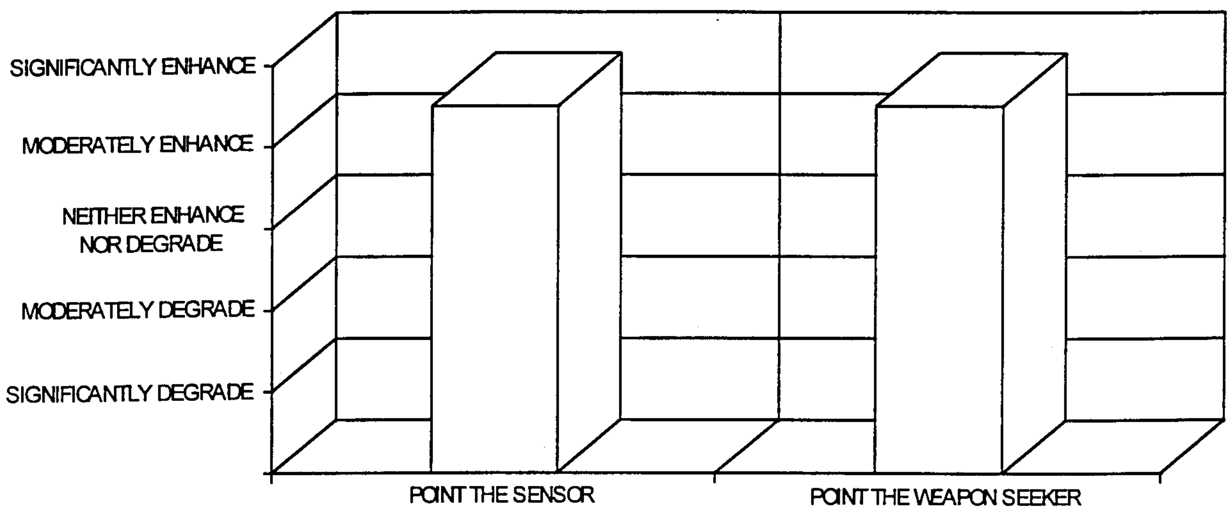

Figure 22. Head Steered Sensor Mechanizations and Their Effects on Performing the IMPACT Mission

Objective Data

Objective data related to the flying task were collected as a tertiary interest to determine any trends that would lend additional insights to the subjective data. It should be remembered that the primary reasons for the interactive flying task were to (1) provide at least a low level of task loading for the pilot rather than using hands off auto terrain following, and (2) improve the projective estimates by having the pilot perform some operational tasks rather than being totally passive. Objective performance data were collected only for the Dual Task conditions; the Head Down treatments did not contain a flying task thus negating the availability of objective data for these treatments.

One note is in order regarding the interpretation of the objective data, however. References for the RMS calculations were the "blackline" course between waypoints (for flight path marker lateral deviation), 300 foot AGL altitude (for the altitude and flight path marker vertical deviations), and 480 kts (for airspeed deviations). Some precision was lost for mission activities where the pilot intentionally deviated from these values. For example, altitude deviations occurred while obtaining the patch map or avoiding a SAM.

Figures 23 through 26 present the results of the objective data that were collected for quantifying altitude, airspeed, and deviations (lateral and vertical) of the flight path marker from the terrain following box. The means and standard deviations were plotted to show the effects of the treatment conditions on measures of central tendency and variability for the respective measures.

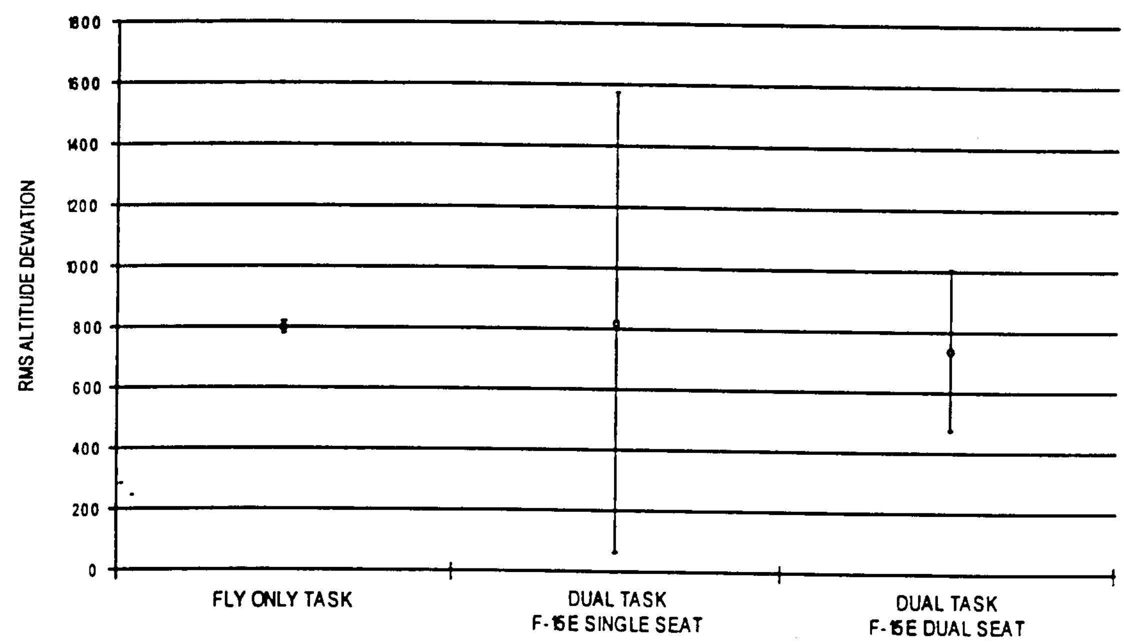

Figure 23. RMS Altitude Means and Standard Deviations

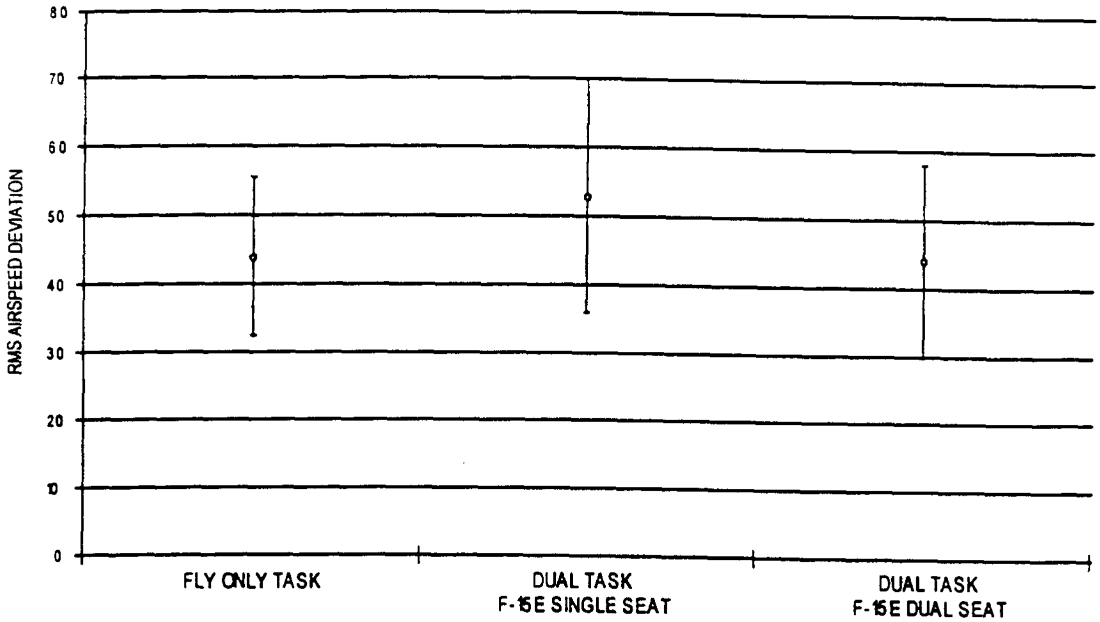

Figure 24. RMS Airspeed Means and Standard Deviations

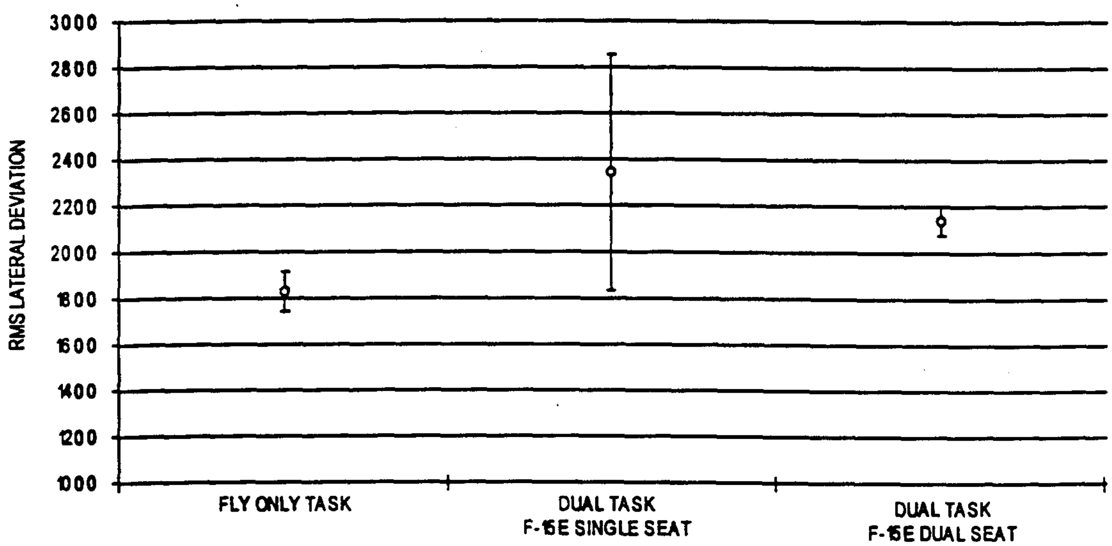

Figure 25. RMS Lateral Deviation - Means and Standard Deviations

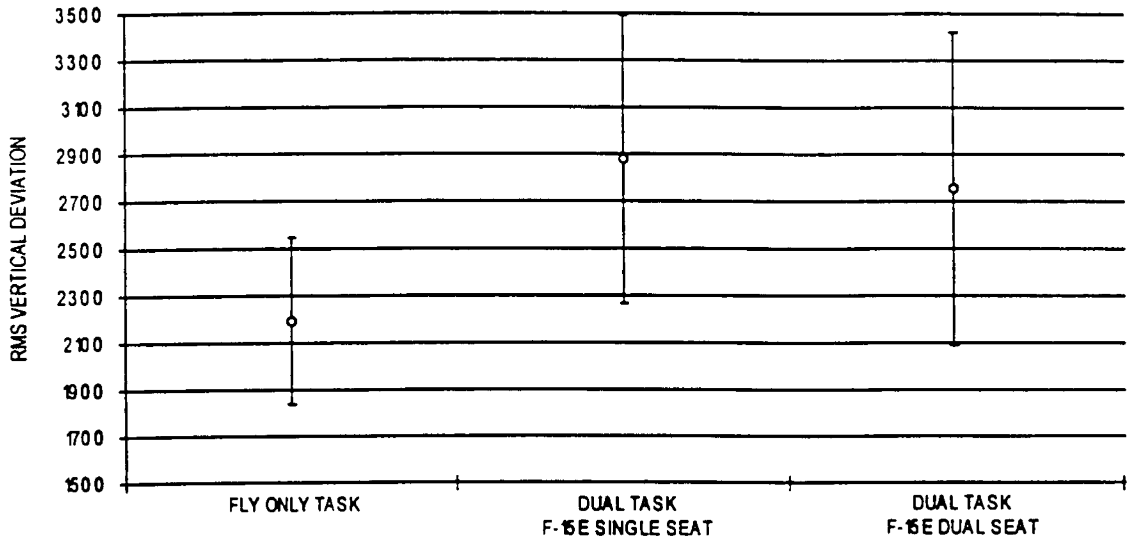

Figure 26. RMS Vertical Deviation - Means and Standard Deviations

DISCUSSION

Workload

Engage Ground Threat. After reviewing the results of the workload data, a question arose concerning the SWAT ratings: Is the psychological stress component of SWAT responsible for the high workload ratings for Engage Ground Threat? The Engage Ground Threat SWAT ratings were examined apart from the other ratings for the dual task conditions (treatments 3, 5 and 6) in an attempt to identify the causative factors for the high workload. Figure 27 presents the ratings averaged across the four pilots and all replications for the Engage Ground Threat event. From this plot it can be observed that the psychological stress component is virtually at the maximum workload rating possible, whereas the time and mental effort dimensions were noticeably lower. It was concluded that the psychological stress dimension was the major contributor to the workload associated with the Engage Ground Threat event, even for Treatment 6, the ATC configuration. As a result, there is some question as to whether PVI enhancements alone can be expected to reduce the psychological stress associated with this mission activity.

Advanced Technologies

Technology Assessment. An objective of the Role Playing exercise was to identify possible cockpit related technologies that could improve the overall effectiveness of a single seat fighter in performing an air interdiction mission at night or in adverse weather. Ratings in Questionnaire Part I were used to assess candidate technologies according to their potential for improving mission effectiveness. The results from these ratings were presented in Figure 8. The ratings were arranged and plotted in descending order to facilitate easier visual inspection. From this plot, it was determined that there were four candidate technologies that were judged to offer the greatest potential for improving mission effectiveness.

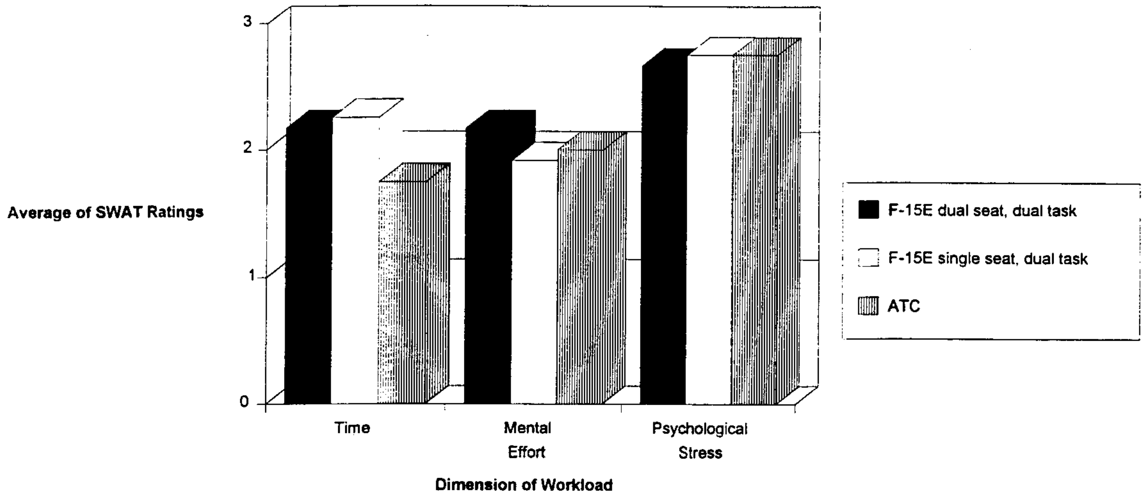

Figure 27. SWAT Ratings for Engage Ground Threat Event

These were:

Sensor Fusion

Data Link

Head Steered Sensor

Helmet Mounted Display

The Head Steered Sensor and Helmet Mounted Display technologies are very closely related and can be visualized as a single technology in many instances. Specifically, a head steered sensor only makes sense if the resulting information is displayed on a helmet mounted display. The helmet mounted display, however, can be used for other purposes in addition to sensor steering.

Within each of the candidate technologies above, additional ratings identified what mission activities might be helped most by the respective technologies. These ratings are presented in Figures 9, 12, 13, and 15. These ratings provide additional insights concerning application of the technology concepts to various mission functions. The plots of the ratings were subjected to a visual inspection noting the frequency and strength of responses from the pilots. Only those activities rated "substantially enhance" by a majority of the pilots were selected for consideration here. While the remaining activities would be assisted to some degree by the respective technologies, they were de-emphasized here because the intent was to identify only the "main" activities likely to be helped.

To further refine the technology assessment, high workload activities needing attention were identified. Ratings from the SWORD questionnaire were presented in Figure 7. Emphasis was given to the conceptual single seat F-15E aircraft ratings since it represents the best blend between real world experiences and approximations to a (futuristic) single seat aircraft. From this plot it was concluded that the highest workload was for the target acquisition function. The second highest workload was for the weapon employment

function, and the lowest workload for the inflight mission replanning function.

Similarly, a plot of SWAT ratings was examined to identify potential workload chokepoints (see Figure 6). It is generally accepted that a SWAT value of 40 or greater indicates pilot activities that can reasonably be expected to compromise mission effectiveness in operational settings (Rueb, et al. 1992; Cone and Hassoun, 1992; Reid and Colle, 1988). From this plot, four "events" were identified as falling into the high workload category:

Engaging a ground threat

Obtaining a patch map

Weapon delivery

Engaging an air threat

The mission change input "event", although a critical mission event, was not rated particularly high in terms of projected workload. As stated previously, the reason for the low workload ratings for this event is the fact that the pilots gave projected workload estimates based on the task of inputting the coordinates and elevations of the new route points and target (via the UFC), and studying the updated route which was displayed on the TSD. The results of the ratings from SWAT and SWORD techniques were compared, and common regions were labeled as high, medium, or low workload as a function of the respective ratings. Finally, narrative responses that accompanied the ratings from Questionnaire Part I were reviewed to identify additional information that was useful for interpreting the SWAT and SWORD ratings. The results are in general agreement that (1) obtaining a patch map and target acquisition are high workload activities, (2) weapon delivery is a medium workload activity, and (3) mission replanning and mission change inputs are low workload activities.

The results from the analyses of the rating scales, SWAT, SWORD, and the narrative responses were integrated and the following technologies were identified as having the greatest potential for improving the overall effectiveness of a single seat fighter in performing an air interdiction mission at night or in adverse weather:

- Sensor fusion would improve probability of target acquisition including a possible reduction in workload.
- Data link would improve threat assessment, enhance situation awareness, and possibly reduce workload.
- Head steered sensor and helmet mounted display would also improve target acquisition and possibly reduce workload.

The reason for stating the "possible" reduction in workload is based upon the difference between technology concepts and technology mechanizations. It is quite common to have pilots rate concepts with a favorable attitude because they are visualized primarily in terms of benefits to the pilot e.g. mission effectiveness, situation awareness, etc. However, once the technology is integrated into the cockpit, there is sometimes an increase in workload as a function of the specific mechanization of the technology. Hence, it can be said that the technologies cited above at least

have the potential for reducing workload but final assessment would be based upon the specific mechanizations.

Ratings and narrative comments for the technologies identified as having only moderate potential for enhancing mission effectiveness (i.e. 3-D audio, speech recognition, and Pilot's Associate) can be found in Appendix D for the interested reader. These technologies were rated as having the potential to "somewhat enhance" the mission but not to the degree of those technologies rated closer to the "substantially enhance" level. The reasons for the clusters of the ratings are not conclusively known. One reason might be that 3-D audio, speech recognition, and Pilot's Associate were not rated higher because they are not similar to current aircraft systems. That is, they may appear to be a departure from current technologies and thus it might have been more difficult to realize their benefits using static simulation.

Control, Display and Automation Candidates. In order to identify possible control, display, and automation candidates necessary for a baseline single seat IMPACT cockpit to perform the air interdiction mission, responses from the questionnaire-Part II, and the results from the workload ratings (SWAT and SWORD) were used to develop trend information. The method for satisfying this objective is depicted in Figure 28. Technologies were identified as having high or moderate potential for enhancing the single seat air interdiction mission, as discussed above. The emphasis here is on those technologies with the highest potential, although some attention is given to the moderate potential technologies to offer some perspective.

The results of the rating scales from Questionnaire Part II were used to prioritize the mechanizations that were presented to the pilots for review. The data from these rating scales were presented in Figures 16 through 22. These ratings were subjected to a visual inspection and those mechanizations receiving the most favorable responses by a majority of the pilots were identified as affording the greatest benefit for the respective technologies.

In addition to the rating scales, additional comments were obtained from the pilots concerning:

- Mechanizations described in the questionnaire
- Potential mission degradation due to technologies
- Suggested additional uses for the technologies

These comments are based upon the pilots' knowledge of the mechanizations from possible experience with related technologies and the IMPACT briefings and simulator missions. The prioritization of technology mechanizations was adjusted as warranted by these comments.

Finally, the results from the SWAT and SWORD workload ratings were examined to determine if additional insights could be obtained about the technology mechanizations. Of particular interest were the single seat workload profiles for the various mission "functions" as depicted in Figures 6 and 7. The workload ratings

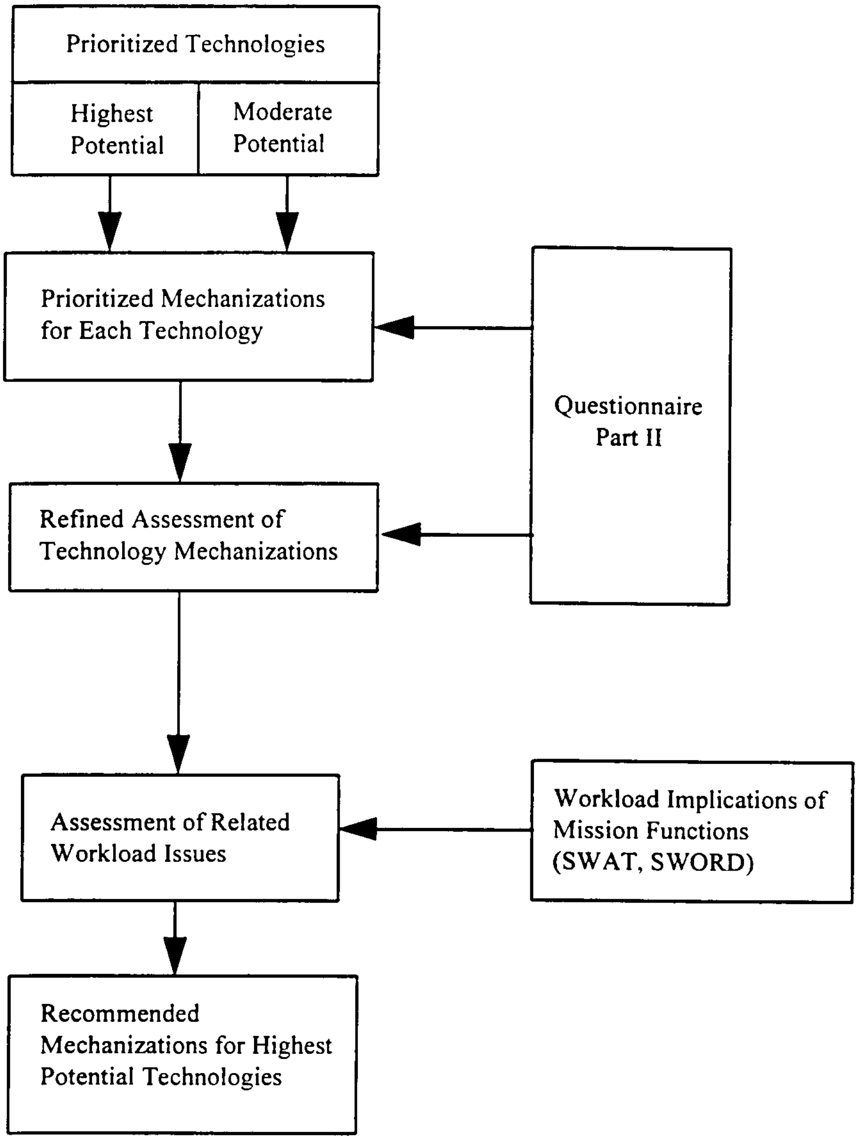

Figure 28. Method for Determining Highest Potential Technologies and Mechanizations

were examined to add another dimension for assessing the technology mechanizations. In other words, a preferred mechanization for any given technology would be of greater interest to pursue if it also applied to mission activities in regions of high workload.

Mechanizations with Highest Potential

Primary emphasis here will be on the mechanizations affording the greatest potential benefits for: (1) sensor fusion, (2) data link, (3) helmet mounted display and (4) head steered sensor. The other technologies will be addressed but with decreased emphasis.

(1) Sensor Fusion. The four most highly rated mechanizations for sensor fusion were:

- Display best fused image (but pilot can switch to single display)
- Synthetically generate display (imagery from multiple sensors)
- Overlay imagery to form one image
- Auto target recognition

Of the above, the results suggest auto target recognition would offer particular benefits because it applies to target acquisition, a high workload task. This is in agreement with the results from Objective 1 where the application of sensor fusion to target acquisition was deemed a valuable application. However, the other, possibly "lower workload" mechanizations, are likely to offer some benefit but the rating scales were intentionally general since they were directed at concept level probes. Hence, the utility of the other sensor fusion mechanizations could not be localized to particular mission phases or pilot functions.

Only one pilot offered any comments regarding cautions applicable to the sensor fusion technology mechanization. Correcting errors and having the ability/authority to select sensor(s) were noted. Although not mentioned, there is some question about the time actually available for selecting various sensor combinations in a fast paced, fluid mission environment. Other comments suggested the application of automation yet retain the ability of the pilot to select the single, preferred sensor. With such a scheme, a pilot could conceivably step through all sensor selections to pick the one that is optimum for given mission conditions; again, whether this is practical from a time perspective remains to be determined. Using sensor fusion for target acquisition was cited as a benefit; this agrees with the ratings from the SWAT and SWORD techniques.

(2) Data Link. Data link offers particular benefits for the high workload associated with enemy airborne and ground based threat avoidance and target attack. To a lesser degree, intel updates and inflight mission retasking and replanning were identified as beneficial mechanizations of the data link technology. It was suggested that further benefits would be realized if awareness of hostiles/targets could be achieved covertly, outside the range of the aircraft's self-contained radar system.

Pilots indicated that intel updates could assist with insuring the correct target was attacked by having imagery available from satellite data (and other) sources. A caution was offered by one pilot for retasking that was received from a distant command, control, and communication (C3) source from the perspective of whether C3 had situation awareness for a very fast-paced fluid environment.

(3) Helmet Mounted Display and (4) Head Steered Sensor. The helmet mounted display and head steered sensor technologies will be discussed together since they are closely related. These two technologies were indicated to increase situation awareness and reduce workload for the following mechanizations:

- Sensor and seeker pointing with respective information display
- Visual acquisition of off boresight bandit and SAM locations

Additional benefits could be realized in conjunction with sensor fusion. For example, an HMD could be used to display fuzed data from millimeter wave radar, FLIR, LLLTV, etc.

Other mechanizations offering lesser benefit are sensor pointing functions for purposes other than engaging targets or bandits (e.g. pointing sensors at a waypoint), and display of aircraft parameters (attitude, altitude, and airspeed).

Some cautions were also cited in the questionnaire:

- Off boresight attitude display could be disorienting.
- Undesired sensor/weapon pointing should be avoided.
- Avoid information display overload that can also clutter HMD "see through".

One pilot indicated that an HMD might assist flying at night and in the weather without the need for automatic terrain following by displaying 3-D (FLIR) terrain imagery on the HMD.

In order for a single seat IMPACT cockpit to perform the air interdiction mission, recommended technologies and mechanizations were identified based upon the results of the study previously described. These findings, along with supporting rationale, are summarized in Table 8.

Mechanizations with Moderate Potential

Although not rated as important as the "High Potential" technologies above, some useful results were obtained for mechanizations applicable to the following technologies: (1) 3-D Audio, (2) Speech Recognition, and (3) Pilot's Associate .

(1) 3-D Audio. 3-D audio was identified as offering benefit if the mechanization was directed at facilitating detection and identification of surface to air threats. Two pilots were concerned that using it as part of ground collision avoidance might be disorienting depending upon the orientation of the pilot's head.

(2) Speech recognition. Speech recognition was identified as offering benefits from several mechanizations:

Radio frequency select
Countermeasure activation
TACAN select
Input of target coordinates
Navigation updates
Mark point input
IFF mode and code select
Fire control
Input of mission data
Selecting sensor field of view
Set up radar display

The benefits of these speech recognition mechanizations were suggested to be reduced workload due to reduced switchology and earlier target identification. However some, drawbacks were likewise identified. Specifically, there was concern expressed that incorrect or unintended commands would be interjected into the total weapon system. Further, excessive voice dependent mechanization might induce missed radio messages.

(3) Pilot's Associate. Pilot's Associate was cited as offering benefits from mechanizations including cueing the pilot of system anomalies, generating

Table 8. Highest Potential Technologies and Mechanizations

Indications from Questionnaire Rating Scales		Technology Mechanizations Yielding Highest Performance Benefit	Rationale and Amplifying Comments from Questionnaire
Technologies with Best Potential	Activities Helped Most		
Sensor Fusion	Fly Aircraft	* Automatic target recognition. * Displaying best fused image.	* Provides knowledge of location and terrain at night and in the weather.
	Navigate	* Generate synthetic imagery from imagery of multiple sensors.	* Provides knowledge of terrain, threats and alternate routes.
	Acquire Target	* Overlay multiple sensor imagery to form one image.	* Provides enhanced probability of target acquisition.
Data Link	Assess Threats	* Intel updates. * Inflight mission replanning.	* Provides enhanced situational awareness.
	Replan Mission	* Confirming bandits without interrogating. * Displaying ground troops in target area.	* Provides rapid data transfer without going heads down.
Head Steered Sensor	Acquire Target	* Point weapon seeker. * Designate points. * Off boresight bandit location indication. * Display of attitude, airspeed, and altitude.	* Display format, and location of information on HMD, should not inhibit target acquisition with respect to where you are looking.
Helmet Mounted Display		* Off boresight target designations.	* Would help indicate where friendlies and hostilities are intermixed during CAS.

routes for retasking, and generating tactics advisories. There would also be a benefit from providing checklist procedures, e.g. for emergencies, that might be too numerous to memorize, or perhaps recall due to combat stress.

Areas for Further Investigation

The following statements and questions represent a list of areas that warrant further investigation. While some of them are not strictly pilot "functions or tasks", they are topics that warrant consideration within the context of the single seat air interdiction mission.

1. Why was the Pilot's Associate technology not rated higher, in terms of mission effectiveness, than many of the other technologies?

2. What types of sensor fusion, versus data fusion, schemes are most desired from a pilot centered perspective?

3. What are the most beneficial functional requirements for inflight mission replanning? Of concern are timeliness of information, pilot authority, and command authority awareness of the pilot's environment.

4. What is the most important information to display on the HMD as a

function of mission phase and what are the display formats?

5. Under the assumption that the psychological stress dimension is the major contributor to workload while being engaged by an airborne or surface threat, what technologies could be applied for reducing workload?

6. What technologies and mechanizations will enhance target acquisition as a function of time available, data/information timeliness, and reliability of data/information?

7. How do the mission functions utilizing sensor fusion drive the algorithm defining sensor fusion?

8. What are the trade-offs for various types of automation used for sensor selection during various mission phases?

9. What guidelines can be developed for data link technology mechanization so that the pilot has the optimum, not maximum, amount of information and data?

10. What are the types, quantities, formats, and update rates for HMD displays that adequately support various mission functions yet do not cause clutter (thus restricting HMD display "look through").

11. What is the optimum blend of ownship versus the "rest of the world" information to be displayed on the HMD as a function of mission phase?

12. What are the constituent pilot functions and tasks that contributed to variations in the mean and standard deviation of the objective performance parameters (altitude, airspeed, and TF commands)?

Verify Test Methodology

Extending beyond the favorable outcomes just discussed, additional sources of information used to verify the overall role playing test methodology consisted of the methodology questionnaires, pilots' verbal comments, and notes and observations based upon the team's experiences during training, data collection, and data processing. Findings from these sources are presented according to the following topic areas: (1) Assessment of role playing methodology from pilots' perspective, (2) Experimental design, (3) Apparatus and (4) Processing of objective data

The project team considered theoretical and practical aspects of the study when addressing verification of the test methodology. Only the most significant findings are presented here although specific responses from the methodology questionnaire can be found in Appendix D for the interested reader.

(1) Assessment of role playing methodology from pilots' perspective. Based upon the responses from Question 2 in the methodology questionnaire, the overall methodology was rated as fair to good. A variation on the methodology was suggested in the form of having the pilot "talk through" the mission; this approach has been used elsewhere but requires identification of suitable "verbal" pilots so that the methodology is not invasive. Other comments were received but suggest other methodologies rather than changes to the role playing methodology. For example, although realistic but time compressed, the scenario was described as just one way of accomplishing the mission. It was suggested that more data could be "measured" if there was more realism.

Responses to questions about the adequacy of training indicated that the pilots rated the training from fair through exceptional with a slight trend toward exceptional.

Concerning the approach of using the single, fixed sequence of mission activities for making projective estimates about workload, pilot ratings (Methodology questionnaire, question #3) were divided between fair and good. One comment was received that deviations from a simple, standardized scenario might induce workload increases due to the deviation alone; while this might be true, there are no additional indications from the other pilots to support this notion. A broader range of technology uses and variations in pilot style, experience base, etc. would be a more global technology assessment. However, for the initial assessment of the technologies, the single, fixed sequence of mission activities was successful.

Per questions four and five in the methodology questionnaire, the SWAT and SWORD techniques were rated identically as good to exceptional. One pilot indicated a slight preference for describing level of workload verbally rather than providing numerical ratings. The pilots appeared to adapt well to SWAT and SWORD and the techniques were not judged to be invasive. The questionnaires and interviews, per responses to question 6 in the methodology questionnaire, received good ratings. One pilot suggested that there was some redundancy of ratings across mission phases. Another pilot suggested integrating Questionnaire I Parts I and II, due to the apparent redundancy, and perhaps due to the overall length of the forms. The apparent redundancy likely stems from the fact that similar questions and ratings were probed several times to gain insights into specific mission phases and/or address technologies and the mechanizations of the technologies. Verbal comments from the pilots suggested that shorter questionnaires would be preferred; a more acceptable alternative might be more extensive use of structured interviews.

(2) ***Experimental design.*** The experimental design used a small number of pilots and a limited number of replications of the treatment conditions. Still, much useful data was obtained and there was general agreement among the various data sources. The partially counterbalanced design was an acceptable, good procedure considering the objectives of this study; there is no evidence of any inadvertent biasing that resulted from the partial counterbalancing. Further, examination of the SWAT data indicated that there was no basis to support the notion that progressive effects existed. In general, it can be said that the design was adequate for addressing PVI issues at the concept and mechanization levels.

(3) Apparatus. The simulator was rated as fair to good with a trend toward good (Methodology questionnaire, question #1). Some desire for more realism was expressed. However, there were no indications that the realism used here in any way compromised the utility of the methodology. Hence, one could question whether or not increased realism is worth the cost if more numerous or more accurate results cannot be guaranteed. The pilot comments were directed primarily toward fidelity:

> There was a desire to have threats that can "kill you".
>
> Impact with the ground should "kill you".
>
> More fidelity, such as having a helmet, was desired.

It was felt that interactive displays would facilitate projection into the pilot's role.

*(4) **Processing of objective data.*** Since collecting objective data was not a primary thrust of this study, procedures were not developed to thoroughly examine these forms of data for detailed, quantitative findings. However, insights were still obtained from the data processing that was accomplished. It is recommended that subsequent studies further examine the utility of objective data as part of the overall role playing methodology. It is suggested that well defined mission segments be established for which to apply specific data probes in order to obtain the required level of diagnostics. While useful insights were obtained by using data that were collapsed across the entire mission, findings were limited to overall trends rather than obtaining detailed, diagnostic information; this was not a flaw in the methodology since it reflects data processing that was commensurate with the test objectives. In future studies, the data probes can be tailored to the functions and tasks being performed within the respective mission segments in order to obtain maximum sensitivity, if required by the study's objectives.

CONCLUSIONS

The IMPACT Role Playing exercise was successful in identifying advanced technologies that will be capable of reducing pilot workload and improving the effectiveness of an air interdiction mission. Sensor fusion, data link, helmet mounted display and head steered sensor were rated by the pilots as the technologies with the highest potential for reducing workload, increasing situational awareness and improving mission effectiveness. In addition, 3-D audio, speech recognition and Pilot's Associate were identified as providing important benefits to the pilot of a single seat fighter.

User input was instrumental in determining possible mechanizations of the technologies. Display of best fused image, automatic target recognition and imagery from multiple sensors were the mechanizations rated most highly for sensor fusion. The pilots stated that imagery fused from multiple sensors would have improved resolution over single sensor imagery, enhancing SA of terrain and mission dynamics. Also, improved sensor imagery and auto target recognition would significantly aid target acquisition and weapons employment capabilities, thus enhancing mission effectiveness.

For a data link system, threat avoidance, inflight intelligence update and mission replanning were the preferred mechanizations. In this case, information (such as mission retasking) linked to the cockpit would reduce time required for voice communication, replanning and head-down time for the pilot to input changes. Also, near real-time threat updates would significantly enhance SA and survivability.

Sensor pointing, and visual acquisition of off-boresight bandit and SAM locations, were the highest rated mechanizations for helmet mounted display/head steered sensor technologies. The use of these devices would decrease the head-down time required for target designation, and greatly enhance threat acquisition (pilot won't have to go heads down to check threat type and location on threat warning display).

From the questionnaire inputs and pilot interviews, it was determined that the role-playing test methodology was an appropriate means to assess pilot workload and recommend technologies and mechanizations. The SWAT and SWORD

techniques were appropriate and useful for assessing projected workload, and were well received by the pilots in this study.

RECOMMENDATIONS

In order to further assess the utility of the advanced technologies, it is recommended that trade studies and part-task simulations be conducted in the following areas: (1) sensor fusion, (2) data link, (3) helmet mounted display and (4) head steered sensor. The objectives of the trade studies should be to assess the current status of research and development efforts in these areas and determine the suitability for the IMPACT program. If the technologies are expected to reach a state of maturity consistent with the year 2005 incorporation date, they should be integrated into a part-task simulation to optimize the PVI.

In addition, part-task studies of 3-D audio, speech recognition and Pilot's Associate should be pursued. Various mechanizations of the technologies should be implemented in the simulator and assessed by the users.

Once the PVI requirements of the individual technologies are determined, all technologies should be integrated into the simulator to assess the combined operational effects. The mechanizations of the technologies and their combined effects should be studied to optimize their integration into a single seat fighter.

REFERENCES

Cone, S. M. and Hassoun, J. A. (1992). Precision Guided Weapons Employment in Single Seat Fighters: A Pilot Workload Assessment. ASD-TR-92-5011, Wright-Patterson AFB, OH.

Eggleston, R. G., (1984). A Comparison of Projected and Measured Workload Ratings Using the Subjective Workload Assessment Technique (SWAT). Proceeding of the National Aerospace and Electronics Conference, Dayton, OH.

Hughes, T.C., Hassoun, J.H., Barnaba, J.M. (1993). A Comparison of Head-Up and Head-Down Display Formats During Instrument Flying Tasks. ASD-TR-93-5003, Wright-Patterson AFB, Oh.

Quinn, T.J., Jauer, R.A., Summers, P.I. (1982). Radar Aided Mission/Aircrew Capability Exploration (RAM/ACE). Task I. System Analysis (Volume I). AFAMRL-TR-82-90, Wright-Patterson AFB, Oh.

Quinn, T.J., Jauer, R.A., Summers, P.I. (1982). Radar Aided Mission/Aircrew Capability Exploration (RAM/ACE). Task II. Synthesis. AFAMRL-TR-82-91, Wright-Patterson AFB, Oh.

Reid, G. B. and Colle (1988). Critical SWAT Values for Predicting Operator Overload. In The Human Factors Society - 32nd Annual Meeting - 1988, Anaheim, CA.

Reid, G. B., Shingledecker, C. A., Hockenberger, R. L., Quinn, T. J. (1984). A Projective Application of the Subjective Workload Assessment Technique. Proceedings of the IEEE Conference.

Rueb, J.D., Barnaba, J.M., Hassoun, J.A., Dudley, R.A., and Ward, G.F. (1992). KC-135 Crew Reduction Feasibility Demonstration Simulation Study, Vol. 3: Test and Evaluation; (ASD-TR-92-5004), Wright-Patterson AFB, OH.

Vidulich, M.A. (1989). The Use of Judgment Matrices in Subjective Workload Assessment: The Subjective Workload Dominance (SWORD) Technique. In Proceedings of Human Factors Society 33rd Annual Meeting, Vol. 2 (pp. 1406-1410). Santa Monica, CA: Human Factors Society.

APPENDIX A

AIR INTERDICTION MISSION NARRATIVES

APPENDIX A - Air Interdiction Mission Narratives

1. F-15E Interdiction Mission

ROLE PLAYING NARRATIVE - F-15E INTERDICTION MISSION

This document is a narrative of the ingress, attack and egress phases of an air interdiction mission. This mission scenario, and associated tasks, will be used to analyze the F-15E aircraft in performing a precision guided munitions attack, with and without the aid of a Weapons Systems Officer (WSO). The results of the analysis will guide the research and development of the IMPACT cockpit. This mission narrative only addresses those functions and tasks which will be performed during the ingress, attack and egress phases of the mission. These phases were selected because they include the highest workload portions of the mission. They will also initially provide the required data to best analyze the affect on pilot performance when the WSO is removed from the cockpit.

ENROUTE

Throughout the mission, the pilot must ***fly the aircraft*** by monitoring and controlling various flight parameters. The specific tasks include using the stick and throttle to fly the aircraft, turn to desired headings, and maintain desired altitude, attitude, and airspeed.

The pilot must also ***monitor the aircraft systems*** by visually checking the engine monitor display, the fuel quantity indicator, the hydraulic pressure indicator, and all caution, warning, and advisory indicators. If any system is not performing as required, the pilot must take corrective actions as appropriate.

The pilot must ***navigate to the contact point***. He must monitor the navigation progress by visually checking the current aircraft position and time to the contact point on the TSD, and comparing that to the planned time and position. The pilot will correct position and timing errors by using the stick and throttle to move the aircraft to the desired position and time.

The pilot will ***contact the command and control aircraft***. On the assigned secure voice frequency, he communicates his status and receives any changes to the route, target or threat. In this scenario, JSTARS gives the pilot the latitude, longitude and altitude of two low level route points, a new target, an egress point and an update to the threat information. The pilot enters the new route and target information into the central computer using the UFC.

The pilot must then ***study the mission data*** (route, terrain, target, threat). He selects 80 NM range on the TSD, studies the route, then selects 40 NM range.

INGRESS

The pilot must now ***navigate to the target*** by selecting TF radar on the right MPD. He descends to the planned ingress altitude by providing stick and throttle inputs for a safe descent. During the descent the pilot must visually check airspeed, altitude, attitude and heading on the HUD. The pilot must perform terrain following and terrain avoidance which includes cross checking the TF radar display with the LANTIRN nav video on the HUD. The pilot must also check the TF system status via the caution, warning, and advisory

system. If a caution, warning or advisory indication is detected the pilot must make the corrective actions. In this scenario, the pilot is flying the manual TF box. The pilot then selects TEWS on the right MPD.

The pilot must monitor the navigation progress by visually checking the current aircraft position and time to the next sequence point on the TSD, and compare that to the planned position and time. The pilot will correct position and timing errors by using the stick and throttle to move the aircraft to the desired position and time.

The pilot must ***set up the A/A radar*** by selecting the appropriate operating mode. The pilot selects RWS-I mode by depressing PB 6 on the MPD. The pilot must then select the desired range setting by slewing the auto acquisition symbol, via the throttle TDC, and bumping the top of the display format to increase the range scale, or the bottom of the display to decrease the range. The pilot then selects his desired azimuth scan volume by slewing the auto acquisition symbol, via the TDC, and bumping the side of the display to increase or decrease the scan limit. The pilot must also select the desired elevation scan by depressing PB 2 on the A/A radar format. This will toggle between 1, 2, 4, 6, & 8, then back to 1.

The pilot must ***perform a precision velocity update (PVU)*** to update the mission navigator. He does this by selecting A/G radar on the left MPD and selecting PVU by pressing PB 6. After waiting approximately 10 seconds, the INS groundspeed errors are displayed. He presses and releases the TDC to accept the update. He rejects PVU by depressing the stick auto acq switch, and selects A/A radar on the MPD.

The pilot must ***confirm the ECM system settings*** by selecting the desired CMD, ICS, RWR, and EWWS operating modes. This is accomplished by the pilot visually verifying that the CMD switch (on the CMD control panel) is set to "MANUAL", the ICS switch is set to "ON" and SET-1 is set to "AUTO" (on the TEWS control panel), the RWR is set to "ON" (on the TEWS control panel), and the EWWS is set to "ON" (on the TEWS control panel). If any of the switch settings are not as required, the pilot must position them to the required position. (*** NOTE: The CMD control panel is only in the F-15E rear cockpit ***)

The pilot must ***monitor the A/A radar*** for enemy aircraft. This is accomplished by visually checking the A/A radar display for airborne contacts.

The pilot must ***monitor ground threats*** throughout the flight. This is accomplished by visually checking the TEWS displays, and listening for aural warnings. If a threat is detected the pilot must identify the threat location and type. This is accomplished by verifying threat information on the TEWS display, and by trying to obtain visual conformation outside the aircraft.

If engaged, the pilot must perform evasive maneuvers to minimize detection/defeat the threat. This is accomplished by using the stick and throttle to fly the aircraft so that the threat is on the beam. He then descends to the lowest practical altitude, checking the HUD nav FLIR video for terrain masking and avoidance. He continues to interpret the TEWS display and scan outside the aircraft to obtain sight of the missile. The pilot will dispense the appropriate chaff/flare program by pulling up on the throttle CMD switch for MAN 1 dispense, or pushing down for MAN

2 dispense. The pilot continues to maneuver to defeat the threat by using the stick and throttle to keep it on the beam. When the threat is defeated, the pilot will resume course.

The pilot will then ***prepare for weapon delivery***. This is accomplished by visually verifying that the MASTER ARM switch is in the "ARM" position and selecting "A/G" master mode on the HUD control panel. In this scenario, selecting A/G master mode brings up the A/G radar on the left MPD, the PACS display on the center MPD, and the TEWS display on the right MPD.

On the A/G radar, the pilot verifies that RBM mode is selected at PB 6, and if RBM is not selected, the pilot must push PB 6 until "RBM" is displayed. The pilot must toggle PB 7 until "MAP" cursor function appears, and select the desired display window size via the stick auto acquisition switch. Pushing the auto acquisition switch forward will decrease the display window size and pulling aft will increase the display window size.

Next, the pilot must select the range and azimuth settings. This is accomplished by pressing PB 13 to decrease the range or PB 14 to increase the range. The desired azimuth setting is full scan, therefore the pilot must depress PB 9 until "FULL" is displayed. The pilot will also activate the video recorder to record radar video by pressing PB 12 on the A/G radar MPD. The pilot then pushes PB 3 on the PACS MPD to get the A/G PACS display. He then confirms the PACS settings. Once this is done, he deselects PACS and selects TSD on the center MPD.

The pilot is now ready to ***obtain a patch map*** of the target area. By pulling up on the throttle coolie switch, the pilot quick steps through the sequence points until the A/G radar is over the target point. The current sequence point is displayed at PB 17 on the radar format.

He must perform a fly-up maneuver to acquire line-of-sight to the target for radar mapping. This is accomplished by providing stick and throttle inputs to obtain line-of-sight to the target.

The pilot can now produce a high resolution patch map of the target and freeze the map for target designation. This is accomplished by pressing and releasing the TDC to get the patch map. When the patch map is constructed, he presses down on the left throttle multi-function switch to freeze the display.

The pilot can now return to low level flight by providing stick and throttle inputs for a safe return to low level flight.

Once the pilot is safely at a low altitude, he will study the radar map display to find the target. Once found, he will slew the radar cursors to the target by moving the throttle TDC. He will then select Target cursor function by pressing PB 7 on the A/G radar MPD.

The pilot will then activate the targeting pod by placing the TGT FLIR switch to "ON", select the TGT IR display on the left MPD, push PB 7 to get "TGT" cursor control, and push PB 10 to get "ATRK" (area track). (*** NOTE: The TGT FLIR switch is only in the F-15E rear cockpit ***).

The pilot will arm the laser by turning the LASER switch to "ARM" (*** NOTE: The LASER switch is only in the F-15E rear cockpit***) The pilot must verify that the

"LASER ARMED" advisory light is illuminated, and the diamond symbol is displayed around the HUD gun cross, and "ARM" is displayed at PB 19 of the Tgt IR MPD.

ATTACK

The pilot is now ready to ***lock the targeting pod onto the target***. He again selects PACS on the center MPD and pushes PB 3 for the A/G PACS display.

The pilot must acquire, update, and lock on the target with the targeting pod. This is accomplished by visually verifying that "TGT" is displayed at PB 7 on the TGT IR format, slewing the Tgt Pod cursors to the target, push forward on the auto acquisition switch on the throttle for narrow field of view (NFOV), use the TDC to slew the cursors over the DMPI, and then push down on the TDC to track the target. The pilot views the Tgt IR display to verify the Tgt IR Pod is tracking the target.

Once the targeting pod is tracking the target the pilot must ***laze the target***. The laser is fired by pushing and releasing the throttle left multi-function switch (laser fire button).

The pilot then maneuvers the aircraft, using the stick and throttle to follow the attack steering cues displayed on the HUD. The pilot will monitor range and time to release by visually checking the range and time information in the HUD.

In this scenario, the pilot will perform DELAYED LAZING. Just prior to weapon release, the pilot will turn off the laser by pressing and releasing the laser fire button.

The pilot will ***release the weapon*** by pressing down and holding the weapon release (pickle) button on the stick. He then watches the release cue move down the HUD Weapons Steering Line until it reaches the flight path marker, at which time the weapon will release. Once the weapon release is successfully accomplished the pilot can release the pickle button.

After weapon release, the pilot will ***fly the laser designation maneuver***. The pilot maintains line of sight to the target by using stick and throttle inputs to maneuver the aircraft away from the target, but maintain Tgt Pod LOS. The pilot checks weapon "time to impact" on the HUD. At five seconds prior to impact, the pilot will lase the target by pressing and releasing the laser fire button The pilot will use the throttle TDC to keep the cursors on the DMPI. After the weapon impacts the target, the pilot will turn the laser OFF by pushing and releasing the throttle left multi-function switch.

The pilot assess target damage by viewing the Tgt IR display. He then undesignates the target by pressing the throttle boat switch AFT. The pilot then turns the LASER switch to SAFE.

EGRESS

The pilot will then ***navigate to the low level exit point***. He selects A/A radar on the left MPD, selects TF radar on the right MPD and selects TSD on the center MPD. He descends to egress altitude by provide stick and throttle inputs. During the descent the pilot must visually check airspeed, altitude, attitude and heading via the HUD. The pilot will perform terrain following and terrain avoidance, which includes cross checking the TF radar display with the LANTIRN nav

video on the HUD. The pilot must also check the TF system status via the caution, warning, and advisory system. If a caution, warning or advisory indication is detected the pilot must make the corrective actions. He then selects TEWS on the right MPD.

The pilot must monitor the navigation progress by visually checking current position on the TSD, and comparing that to the planned position. The pilot will correct position errors by using the stick and throttle to move the aircraft to the desired position.

The pilot must ***monitor the aircraft systems*** by visually cross checking the engine monitor display, the fuel quantity indicator, the hydraulic pressure indicator, and all caution, warning, and advisory indicators. If any system is not performing as required, the pilot must take corrective actions as appropriate.

The pilot will ***confirm the ECM system settings*** by selecting the desired CMD, ICS, RWR, and EWWS operating modes. This is accomplished by the pilot visually verifying that the CMD switch (on the CMD control panel) is set to "MANUAL", the ICS switch is set to "ON" and SET-1 is set to "AUTO" (on the TEWS control panel), the RWR is set to "ON" (on the TEWS control panel), and the EWWS is set to "ON" (on the TEWS control panel). If any of the switch settings are not as required, the pilot must position them to the required position. (*** NOTE: The CMD control panel is only in the F-15E rear cockpit ***)

The pilot must ***monitor air threats***. He selects A/A master mode on the HUD control panel, which brings the A/A radar up on the left MPD and the PACS display on the center MPD and TEWS on the right MPD. He pushes PB 2 on the PACS MPD to get the A/A PACS display. He then confirms the A/A PACS settings. In this scenario, the throttle missile select switch is in the forward (MRM) position, and an AIM-120 is ready to be launched.

The pilot then visually checks the A/A radar display for airborne contacts. If an airborne target is detected the pilot must designate the target by slewing the acquisition symbol over the target symbol and then depressing and releasing the throttle TDC.

Once the target is designated the pilot must perform an IFF interrogation to further ID the target. The interrogation is performed by pressing outboard and holding the throttle coolie switch. If the interrogation verifies that the target is hostile, the pilot must engage the enemy aircraft by confirming that the master arm switch is set to "ARM", waiting for the target to be in range, and pressing the pickle button to launch the missile.

The pilot must ***monitor the aircraft systems*** by visually cross checking the engine monitor display, the fuel quantity indicator, the hydraulic pressure indicator, and all caution, warning, and advisory indicators. If any system is not performing as required, the pilot must take corrective actions as appropriate.

The pilot must also ***monitor ground threats.*** This is accomplished by visually checking the TEWS displays, and listening for aural warnings.

2. ATC Interdiction Mission

ADVANCED TECHNOLOGY COCKPIT INTERDICTION MISSION

Blasting along at 480 knots, Jack adjusted the temperature in his fighter cockpit and checked the distance remaining to the contact point. His mission tonight was to take out a chemical weapons production and storage facility in the Iraqi desert, recently imaged by an Aurora reconnaissance aircraft. Under the wings of his jet were four JDAM 2000# bombs, finally operational after years of research and development. Smart launch and leave weapons, the JDAMs were nothing more than a slick BLU-109 bomb with a GPS guidance package attached. Put the target coordinates into the weapon, and today's pilot could drop an incredibly precise bomb, in all weather conditions, outside of most enemy defenses. "Not like the early 90's", he thought, recalling his first F-15E tour to Elmendorf AFB as a gung-ho first lieutenant. The most precise weapons at that time were laser guided bombs, and the weather had to be fairly decent to send one through the front door of an aircraft shelter. "Amazing...", he mused to himself. The advances made in fighter cockpits over the past 15 years have really made weapon employment easier. "They're finally talking to some pilots when designing these things, I guess."

Screaming into the blackness of the Southwest Asian night, he scanned his air-to-air radar for trouble as he proceeded to the contact point, where he'd data link his "AS FRAGGED" status to a JSTARS command and control aircraft orbiting a couple hundred miles away. He was on his sixth mission since deploying here, and was looking forward to doing some damage tonight.

"MESSAGE"..."MESSAGE"..."MESSAGE" ...

The word flashed in his wide field-of-view Head-Up Display (HUD) once every second, telling him that the JSTARS (or some other Command and Control agency) was sending him a message. Pushing the DATA button on the HUD control panel cleared the advisory from his HUD and displayed a message on his full color Tactical Situation Display (TSD).

JSTARS RETASK FOR PYTHON 1

SP1: N3104.6 E4358.1 ELEV 200 PEAK

SP2: N3122.1 E4358.9 ELEV 280 PEAK

SP3: N3132.3 E4346.4 ELEV 230 BRIDGE

TARGET: SCUD LAUNCHER WITHIN 5NM OF SP3

TOT: ASAP

THREATS: UPDATED

This message, sent by secure data link, was Higher Headquarters' way of saying, "We've got a change of plans for you". With the simple voice command "ACCEPT DATA", the mission was loaded into the fighter's central computer and the route displayed on the TSD. In addition, updated surface threat locations were added to the display, giving Jack a real time, accurate, secure update of the enemy ground order of

battle. What a quantum leap from recent years, when most communication was by voice over UHF or VHF radios, in the distorted KY-58 secure mode. No more typing the data onto a keypad either...nearly everything these days was automated.

PROSWAT ____________

Jack had little time to study the route, for the first Sequence Point (SP) was only 2 miles away. He banked his jet hard right to approximately 50 degrees, and started a descent to low altitude. Once on course, the autopilot would keep the jet on the proper headings. He entered clouds during the descent, and by the looks of things he'd be in them for a while. His Helmet Mounted Display (HMD), which was integrated with a head-steerable sensor, displayed the terrain below him and to the sides with incredible clarity. Similar to the LANTIRN navigation video, this system was much better in that it worked in any weather...The HMD made "seeing through the weather" a reality. As he leveled at 300 feet, he checked his air-to-air radar to confirm the proper settings. His search mode was a combination of high and medium Pulse Repetition Frequencies (PRF), was looking out 40 miles in front of his aircraft, and was taking full advantage of the 160 degree azimuth scan. "Nobody out flying tonight", he muttered into his MBU-12P oxygen mask. "Too bad...wouldn't mind painting another enemy flag on my fuselage. Can't believe we're still dealing with the countries in this region...14 years after Desert Storm..."

A few more glances at the air-to-air radar, and he switched his attention to the Integrated Air to Ground Sensor. It was more than a ground map radar, more than an IR imager. This device continuously fuzed the images of several emitters and imagers to give the pilot the best possible display for navigation, target acquisition and weapons delivery. The movement of a couple HOTAS switches set the range and azimuth scan of this unit. On every sortie he flew, whether day or night, he was amazed at the accuracy and resolution of this new device. It was usable in any weather, and if the weather was good, he could slew it to ground targets using the HMD.

Once satisfied that his sensor was set properly for the upcoming task, Jack turned his attention to avoiding the many threats scattered about this region of the enemy's territory. He looked at his advanced threat warning display, which showed occasional "hits" from Surface-to-Air Missile (SAM) acquisition radars. The enemy, he knew, had his radars up and operating. Any target worth destroying is worth defending. Scanning the perimeter of the display, he confirmed the various operating mode settings. The internal jamming was coupled to the advanced chaff and flare dispensers, and all were commanded by the Threat Warning System (TWS). Another feature that gave Jack a warm fuzzy was the fact that the HMD was integrated to the TWS, allowing a pilot who was fired upon by a SAM to look quickly in the direction of the emitter, enabling him to get an early tally-ho on an inbound missile. These systems were used in conjunction with 3-D audio, which put warning tones in the headset in such a way that the pilot could tell threat location based on sound. He glanced at his TSD to see where the latest threats were reported to be, when

"BEEPBEEPBEEPBEEPBEEPBEEPBEEP. ..."

The rapid staccato tones in his earphone instantly increased Jack's heartbeat and directed his eyes to his left 11 o'clock. His

HMD displayed an "8", denoting a mobile Soviet made SA-8 GECKO missile launch commanded by the LAND ROLL radar. Simultaneously, instinctively, Jack grasped the control stick tight as he rolled his 68,000# aircraft to the right, descending slightly, and rolling out again when the threat tones and HMD-displayed symbol were directly off his left wing. "Missile inbound....?" he wondered as he searched the horizon to his left, occasionally glancing forward to make sure he wasn't about to fly into the ground. "THERE". It was easily discernible, the booster still burning, the small missile arcing upward and tracking slightly forward on his canopy, still a couple miles away. The TWS automatically dispensed the appropriate chaff program designed to defeat this short range SAM. That, combined with his beaming maneuver, seemed to have defeated the enemy target tracking radar, for the missile now was veering off to the left. Suddenly it dove for the ground and exploded in a fireball about a mile off his wing. The HMD symbols and headset tones were becoming intermittent now as the enemy radar operators searched for but couldn't quite find that high speed contact at which they just launched a missile. Banking hard left to return to course, Jack kept the general threat location on his beam. The "8" and the tones disappeared for good as he intercepted his planned route.

PROSWAT ___________

Now about 20 miles from the target, Jack could continue to spend his time avoiding and negating the air and surface threats. In the past, he would have had to begin offsetting the target area and making a patch map with a high resolution radar. Now, with this integrated, multi-sensor-fuzed display, he could stay low, below enemy radar coverage until much closer to the target, and be assured of target acquisition. He confirmed that his Master Arm switch was set to "ARM" and the air to ground delivery mode selected. Still no enemy aircraft to be seen, he pressed on at 8 miles a minute, using his HMD to scan the rocky desert terrain ahead .

The Pilot Associate system, a new computer that monitors aircraft system performance and recently installed during the last depot visit, was silent. If any subsystem, (engine, hydraulic system, fuel system, etc.) were to start behaving abnormally, the pilot associate would alert the pilot and recommend appropriate courses of action. So far tonight, the jet was flying great. Jack flew to SP 3, the last point prior to the target, overrode the autopilot with the stick paddle switch and banked left toward the target. The closer to the target area he got, the more intense his concentration on the upcoming tasks. "Hope that Scud launcher won't be too hard to find," he thought.

At 15 miles from the bridge, he started a slight climb so the air to ground sensor could get a direct line of sight (LOS) to the target area. "The Scud should be within 5 miles of the bridge, or so they say", he mumbled. The sensor has an Automatic Target Recognition (ATR) feature which can discriminate between possible targets and natural, non-man-made objects. In the not so distant past, the pilot would look at the radar/FLIR image and have to decide which of the objects on the display was the target. With ATR, the central computer synthesizes the various images and decides what's a possible target and what's not (reducing the effectiveness of decoys). Also, it can detect and track up to ten targets, giving the pilot the opportunity to select which one to attack.

With that capability, and the lack of man-made objects out in the desert, the sensor should be able to pick out the Scud with no problem.

Following the attack steering displayed on the HUD, Jack accelerated to 540 knots ground speed. He was flying just high enough above the desert floor so the sensor could get a good look at the bridge and surrounding area. The many mobile SAMs known to be in this location are what drove Jack's low altitude ingress...otherwise he could have stayed farther away from the target and dropped his weapons from a much higher altitude. The sensor was slewed to the target area, and the image it displayed on the Multi-Purpose Display (MPD) quickly changed from a rough "ground map-like" picture to a much more highly detailed, high resolution map, to an almost TV-like picture ("an improved LANTIRN image", he thought). All this, automatically, and while he was still in the clouds and haze. The ATR placed a box around the bridge in the center of the MPD, for that was a possible target. Four other boxes were grouped together on the right side of the display. "Piece of cake", he thought. Knowing that the bridge wasn't the target, Jack designated the other group and commanded the sensor to a magnified view. Approaching 7 miles to this newly-selected target, Jack watched the display grow clearer until he recognized the Scud launcher. "Bingo!", he whispered. Parked nearby were three other vehicles: a fuel truck, a weather van and a smaller command and control vehicle. A quick slew with his left forefinger and the sensor locked onto the long, semi-tractor trailer with the Russian made Scud missile strapped to its top. The sensor is also smart enough to know the exact latitude and longitude of the designated target, and downloaded these to the JDAM's guidance section.

PROSWAT ___________

His threat warning system occasionally chirped, displaying the symbols for the 2S6 antiaircraft artillery/SAM vehicle and other mobile SAM radars in their search modes. "They're looking, but can't see me...either I'm too low for their radars to pick me out of the ground clutter, or the internal ECM is wreaking havoc with their scopes". Approaching 3 miles to the Scud, Jack slammed the throttles into MIL power and started a shallow climb. At 2 miles, and 20o nose high, with thumb on the pickle button and HUD flight path marker on the attack steering line, the fighter's central computer sent an electrical signal to the release mechanisms in the weapon pylon. This action electrically fired the cartridges, and the rapidly expanding gas sprung open the two hooks holding the 2000# weapon. This was immediately followed by the downward firing of the two ejector pistons, which pushed the bomb away from the aircraft with a noticeable THUD. Jack released the pickle button, rolled his jet nearly inverted to the right, and pulled back down to low altitude. With his head up, he looked forward to avoid the terrain and proceeded to the egress point. The sensor was still locked onto the Scud, its video displayed on Jack's MPD. Twenty seconds after release, the Scud launcher and two of the support vehicles disappeared in the overwhelming conflagration caused by the rapid expansion of 550 pounds of Tritonal high explosive. Half a second later, a large secondary explosion signaled the end of life for the Scud's tanker support truck.

PROSWAT ___________

Smiling under his oxygen mask, Jack again turned his attention to the air-to-air

radar and avoiding threats. He made a quick glance at the threat warning display to confirm the ECM system settings, checked the air-to-air radar, and scanned the terrain outside the aircraft using the HMD. Shortly thereafter, a contact appeared on his radar. "No other friendlies supposed to be in this area", he thought as he designated the contact and performed electronic interrogation to determine if this guy was a "friend" or "foe". No friendly replies on any of the IFF modes brought another smile to Jack's face. "You picked the wrong night, pal" Jack murmured as he selected the medium range missile attack mode and patiently waited until the target was within "no escape" range. The bandit's aspect was hot, meaning he was pointing at Jack, but a lack of threat warning symbology and radar display jamming led Jack to conclude that this guy didn't see him. "He'll never know what hit him...", Jack thought as the radar display indicated that the bandit was within range of his stealthy, improved AMRAAM. "Fox III", Jack whispered as his right thumb pushed the pickle button to eject the missile from his aircraft. Its motor ignited and away it screamed, the rocket exhaust illuminating the clouds around his jet as it streaked toward its unsuspecting victim. Shortly thereafter, the radar indicated that the missile timed out. With a lack of an airborne contact on the display, Jack accurately concluded that a third kill was his.

OVERALL PROSWAT ________

PROSWAT ____________

Another 50 miles, and he'd begin his climb to the fragged refueling altitude. JSTARS, to whom he'd relay his mission success, will most likely have additional tasking for him. "After all", he thought, "there are plenty of targets out there, and the night is still young".

APPENDIX B

MISSION CHECKLISTS

APPENDIX B - Mission Checklists

1. Pilot and WSO Configuration

INTERDICTION MISSION CHECKLIST (Pilot and WSO)

1.2 MONITOR AIRCRAFT SYSTEMS
- Engine
- Fuel
- Hydraulics
- Warning/Caution lights

1.3 NAVIGATE TO CONTACT POINT
- Check aircraft position on TSD

1.4 CONTACT JSTARS

"Dark Star, Eagle 1 as fragged"

"Eagle 1, Dark Star copies as fragged...You've

been retasked, advise when ready to copy"

"Eagle 1, ready to copy"

"Eagle 1, first steerpoint...North 3104.6...East 4358.1...200 ft...hill"

"Eagle 1 copies"

"Second steerpoint...North 3122.1...East 4358.9... 280 ft...hill"

"Eagle 1 copies"

"Target...North 3132.3...East 4346.4...230 feet...bridge"

"Eagle 1 copies"

"Egress point...North 3157.2...East 4401.2...100 feet....hill"

"Eagle 1 copies"

"Eagle 1, those target coordinates are for a north/south bridge...Your target is a Scud missile launcher, observed 10 minutes ago with three support vehicles heading east from that bridge through the desert ...Estimate the current Scud position within 4 miles of the bridge...how copy?"

"Eagle 1 copies all"

(WSO inputs route and target coordinates via UFC)

"Eagle 1, threat update...SA-8s and AAA located at the bridge and along the road north and south of the bridge...Possible SA-6 also...Enemy air activity is low...how copy?"

"Eagle 1 copies"

1.5 STUDY NEW ROUTE
- Select 80 NM range on TSD; study route and terrain
- Select 40 NM range on TSD

2.2 MONITOR AIRCRAFT SYSTEMS
- Engine
- Fuel
- Hydraulics
- Warning/Caution lights

2.3 NAVIGATE TO TARGET
- Select TF Radar - castle switch RIGHT
- Study TF Radar display
- Select TEWS - castle switch RIGHT twice
- Check aircraft position on TSD

2.4 Set up A/A Radar
- RWS-I
- TDC to top/bottom of display for desired range
- TDC to left/right of display for desired azimuth scan
- PB 2 for desired el scan

2.5 PERFORM PVU

(WSO takes command of the A/G Radar, performs PVU)

- Take command of A/A Radar - castle switch down & release, then left

2.6 Confirm ECM System Settings

(WSO confirms ECM system settings)

2.7 MONITOR AIR THREATS

2.8 MONITOR AIRCRAFT SYSTEMS
- Engine
- Fuel
- Hydraulics
- Warning/Caution lights

2.9 MONITOR GROUND THREATS

2.10 PREPARE FOR WEAPONS DELIVERY
- MASTER ARM - ARM
- A/G Master Mode - SELECT
- A/G PACS display - SELECT (PB 3)
- Confirm PACS settings

(WSO takes command of A/G radar, confirms A/G Radar settings, verifies TGT FLIR ON, selects Tgt IR display on his MPD)

- Select TSD - castle switch AFT twice

2.11 OBTAIN PATCH MAP
- Fly up to obtain LOS (1500AGL, 8NM from SP 3)

(WSO quick-steps radar cursors to target, commands patch map, freezes display)

- Fly back down to low altitude

(WSO studies radar display, slews cursors to target, selects TGT cursor function, arms LASER)

- Takes command of A/A Radar - castle switch LEFT twice, down, LEFT

2.12 MONITOR AIR THREATS

3.1 LOCK TARGETING POD ON TARGET
- Select Tgt IR pod on left MPD - castle switch LEFT twice
- Select PACS - castle switch AFT
- Select A/G PACS display - PB 3

(WSO records Tgt IR video, slews TGT POD cursors to target, goes NFOV, designates target)

3.2 LASE TARGET

(WSO fires LASER)

- Follow AUTO steering mode in HUD
- At approx. 13,000 feet slant range (2.2 NM), pull up to 10^{o} nose high

(WSO stops lazing just before weapon release)

- Release weapon - PRESS and HOLD pickle button

3.4 FLY LASER DESIGNATION MANEUVER
- Check 60^{o} right
- Descend to low altitude
- Maintain LOS to target

(WSO keeps cursors on target; at 5 sec until impact, WSO lazes target; confirms weapon impact, stops lazing, performs BDA, undesignates target, turns off LASER)

4.1 NAVIGATE TO LOW LEVEL EXIT POINT
- Select A/A Radar - castle switch LEFT
- Select TF Radar - castle switch RIGHT
- Select TSD - castle switch AFT twice
- Study TF Radar display

- Select TEWS - castle switch RIGHT twice

4.2 MONITOR AIRCRAFT SYSTEMS
- Engine
- Fuel
- Hydraulics
- Warning/Caution lights

4.4 MONITOR AIR THREATS
- A/A Master Mode - SELECT
- A/A PACS display - SELECT (PB 2)
- Confirm PACS settings
- Lock onto radar contact - TDC PRESS and RELEASE
- Interrogate contact - coolie switch outboard and HOLD
- Confirm hostile - no diamond/circle in HUD
- Launch AIM-120 - PRESS pickle button

4.5 MONITOR AIRCRAFT SYSTEMS
- Engine
- Fuel
- Hydraulics
- Warning/Caution lights

4.6 MONITOR GROUND THREATS

APPENDIX B - Mission Checklists (cont.)

2. Pilot Only Configuration

INTERDICTION MISSION CHECKLIST (Pilot only)

1.2 MONITOR AIRCRAFT SYSTEMS
- Engine
- Fuel
- Hydraulics
- Warning/Caution lights

1.3 NAVIGATE TO CONTACT POINT
- Check aircraft position on TSD

1.4 CONTACT JSTARS

"Dark Star, Eagle 1 as fragged"

"Eagle 1, Dark Star copies as fragged...You've been retasked, advise when ready to copy"

"Eagle 1, ready to copy"

"Eagle 1, first steerpoint...North 3104.6..East 4358.1...200 ft...hill"

"Eagle 1 copies"

"Second steerpoint...North 3122.1...East 4358.9...280 ft...hill"

"Eagle 1 copies"

"Target...North 3132.3...East 4346.4...230 feet...bridge"

"Eagle 1 copies"

"Egress point...North 3157.2...East 4401.2..100 feet....hill"

"Eagle 1 copies"

"Eagle 1, those target coordinates are for a north/south bridge...Your target is a Scud missile launcher, observed 10 minutes ago with three support vehicles heading east from that bridge through the desert ...Estimate the current Scud position within 4 miles of the bridge...how copy?"

"Eagle 1 copies all"

"Eagle 1, threat update...SA-8s and AAA located at the bridge and along the road north and south of the bridge...Possible SA-6 also...Enemy air activity is low...how copy?"

"Eagle 1 copies"

- Input Latitude, Longitude and Elevation via UFC:

2, PB 10, PB 10
SHF, N, 31046, PB2
SHF, E, 043581, PB 3
200, PB 7

3, PB1
SHF, N, 31221, PB2
SHF, E, 043589, PB 3
280, PB 7

4., PB1
SHF, N, 31323, PB 2
SHF, E, 043464, PB 3
230, PB7

5, PB1
SHF, N, 31572, PB 2
SHF, E, 044012, PB 3
100, PB7
MENU

1.5 STUDY NEW ROUTE
- Select 80 NM range on TSD; study route and terrain
- Select 40 NM range on TSD

2.2 MONITOR AIRCRAFT SYSTEMS
- Engine
- Fuel
- Hydraulics

- Warning/Caution lights

2.3 NAVIGATE TO TARGET
- Select TF Radar - castle switch RIGHT
- Study TF Radar display
- Select TEWS - castle switch RIGHT twice
- Check aircraft position on TSD

2.4 Set up A/A Radar
- RWS-I
- TDC to top/bottom of display for desired range
- TDC to left/right of display for desired azimuth scan
- PB 2 for desired el scan

2.5 PERFORM PVU
- Select A/G Radar - castle switch LEFT
- Select PVU - PRESS PB 6
- When errors are displayed, press and release TDC
- Reject PVU - auto acq switch DOWN
- Select A/A Radar - castle switch LEFT twice

2.6 Confirm ECM System Settings
- CMD - MAN
- ICS - ON
- Set-1 - AUTO
- RWR - ON
- EWWS - ON
- TONE - set

2.7 MONITOR AIR THREATS

2.8 MONITOR AIRCRAFT SYSTEMS
- Engine
- Fuel
- Hydraulics
- Warning/Caution lights

2.9 MONITOR GROUND THREATS

2.10 PREPARE FOR WEAPONS DELIVERY
- MASTER ARM - ARM
- A/G Master Mode - SELECT
- Confirm A/G radar settings
  - RBM mode
  - MAP at PB 7
  - 4.7 Display Window at PB 8
  - FULL scan at PB 9
  - 20 NM range
- Record A/G RDR video - PRESS PB 12
- A/G PACS display - PRESS PB 3
- Confirm PACS settings
- Select TSD - castle switch AFT twice

2.11 OBTAIN PATCH MAP
- Quick step to target - coolie switch UP
- Fly up to obtain LOS (1500AGL, 8 NM from SP 3)
- Command patch map - TDC PRESS and RELEASE
- When map is displayed, FREEZE patch map - left multifunction switch PRESS AND RELEASE
- Fly back down to low altitude
- Study radar display
- Slew cursors to target
- Select TGT cursor function - PRESS PB 7
- Command TGT cursor function - TDC PRESS and RELEASE
- Verify TGT FLIR switch - ON
- Select Tgt IR on left MPD - castle switch LEFT
- Select ATRK - PRESS PB 10
- Arm LASER - LASER switch ARM

(ARM displayed at PB 19, LASER ARM light on, diamond around HUD gun cross,)

3.1 LOCK TARGETING POD ON TARGET

- Select PACS - castle switch AFT
- Select A/G PACS display - PRESS PB 3
- On TGT IR display, verify TGT above PB7
- Slew Tgt Pod cursors to target
- Select NFOV - auto acq switch FWD
- Designate the target - TDC PRESS and RELEASE
- Verify TGT IR pod is tracking the target

3.2 LASE TARGET

- Fire LASER - left multifunction switch PRESS AND RELEASE
- Follow AUTO steering mode in HUD
- At approx. 13,000 feet slant range (2.2 NM), pull up to 10o nose high
- Stop lazing just prior to weapon release - left multifunction switch PRESS AND RELEASE
- Release weapon - PRESS and HOLD pickle button

3.4 FLY LASER DESIGNATION MANEUVER

- Check 60^{o} right
- Descend to low altitude
- Maintain LOS to target
- At 5 sec prior to impact, Fire LASER - left multifunction switch PRESS AND RELEASE
- Keep TGT Pod cursors on DMPI until impact
- Turn off LASER - left multifunction switch PRESS AND RELEASE
- Perform BDA
- Undesignate target - boat switch AFT
- LASER switch - SAFE

4.1 NAVIGATE TO LOW LEVEL EXIT POINT

- Select A/A Radar - castle switch LEFT
- Select TF Radar - castle switch RIGHT
- Select TSD - castle switch AFT twice
- Study TF Radar display
- Select TEWS - castle switch RIGHT twice

4.2 MONITOR AIRCRAFT SYSTEMS

- Engine
- Fuel
- Hydraulics
- Warning/Caution lights

4.4 MONITOR AIR THREATS

- A/A Master Mode - SELECT
- A/A PACS display - PRESS PB 2
- Confirm PACS settings
- Lock onto radar contact - TDC PRESS and RELEASE
- Interrogate contact - coolie switch outboard and HOLD
- Confirm hostile - no diamond/circle in HUD
- Launch AIM-120 - PRESS pickle button

4.5 MONITOR AIRCRAFT SYSTEMS

- Engine
- Fuel
- Hydraulics
- Warning/Caution lights

4.6 MONITOR GROUND THREATS

APPENDIX C

QUESTIONNAIRES AND RESPONSES

APPENDIX C - Questionnaires and Responses

1. Technology Assessment: Part I

IMPACT ROLE PLAYING QUESTIONNAIRE INSTRUCTIONS PART I

The purpose of this questionnaire is to obtain your assessment of advanced technologies as they were implemented in the Advanced Technology Cockpit (ATC) mission narrative. We will be asking you to determine how the technologies in the ATC would affect your performance, situational awareness and mission effectiveness compared to that provided by the F-15E cockpit you used in the role-playing exercise. For each question, enter the appropriate letter in the blank to indicate whether your performance, situational awareness or mission effectiveness would be improved or degraded from the F-15E cockpit. The scale is provided at the bottom of each page for your reference. In addition to the ratings, we ask for comments on each question for you to explain your answer. These comments are important to us and will aid our interpretation of the data.

Base your answers on your walk-through of the ATC mission scenario, the implementations of the technologies in that scenario, and the advanced technology briefing you were given during the training session. If you have questions or need clarification on any item, please ask the test engineer.

IMPACT ROLE PLAYING QUESTIONNAIRE
PART I

I. Helmet Mounted Display (HMD) - Based on the implementation of the HMD in the ATC air interdiction mission narrative, please enter your rating in the blank using the following scale. Use the conceptual F-15E single seat cockpit as a basis for comparison:

1. The HMD would ________ my ability to FLY THE AIRCRAFT.

RATING	NUMBER OF RESPONSES
1. Substantially Enhance	2
2. Somewhat Enhance	2
3. Not Affect	0
4. Somewhat Degrade	0
5. Substantially Degrade	0

HOW?

S1: "Assuming at night/wx, with possible 3-D video, we could fly out of present TF limits with visual terrain avoidance."
S2: "SA would be higher if I could see the terrain while looking in almost any direction. However, the terrain would need to be as if daytime so there is no disorientation - i.e., no sideway moving pictures etc."
S3: "Allow me to determine aircraft attitude while "heads up" looking somewhere (i.e., checking six) other then through the HUD, especially at night or in poor weather conditions."
S4: "It would allow me to fly or monitor flight looking out the sides and checking 6 o'clock."

2. The HMD would ________ my ability to NAVIGATE.

RATING	NUMBER OF RESPONSES
1. Substantially Enhance	1
2. Somewhat Enhance	1
3. Not Affect	2
4. Somewhat Degrade	0
5. Substantially Degrade	0

HOW?

S1: 'Navigation is no longer a big problem - especially with data link coupled with GPS."
S2: "For same reasons as above. SA would be greater knowing direction etc. all the time in the HMD."
S3: No comment
S4: No comment

3. The HMD would ________ my ability to MANAGE THREATS.

RATING	NUMBER OF RESPONSES
1. Substantially Enhance	2
2. Somewhat Enhance	2
3. Not Affect	0
4. Somewhat Degrade	0
5. Substantially Degrade	0

HOW?

S1: "Threat axis or maneuvers out of TF."
S2: "Depends exactly on technology. If I could see the threats at night (NVG type stuff) then it probably greatly enhances. However, for simple info on threats audio would be better."
S3: "Would give me real time threat awareness without requiring me to go "heads down" to look at TEWS scope to see what quadrant I need to 1) start looking for the threat, be it SAM, AAA or AI 2) start maneuvering the aircraft the avoid / defeat the threat."
S4: "It would help alot if it could cue me into looking and finding threats quickly."

4. The HMD would ________ my ability to ACQUIRE TARGETS.

RATING	NUMBER OF RESPONSES
1. Substantially Enhance	3
2. Somewhat Enhance	1
3. Not Affect	0
4. Somewhat Degrade	0
5. Substantially Degrade	0

HOW?

S1: "By not being limited to an "on axis" (AL) viewing of threat arrays. No longer "heads down" time sharing of target aq. vs. HUD flying."
S2: "See from any angle without be tied to the soda straw of the HUD."
S3: "This statement assumes that I can visually see the target. Many times our deliveries require designation of targets and even delivery of wpns BVR (beyond visual range). Also since most F15E mission requirements are night oriented, NVG's would be required (weight!) for this technology. This HMD target acquire capability would be beneficial in a CAS aircraft were multiple friendly and enemy forces are intermixed (tanks on battle field), but for long distant deliveries of advanced weapons from strike aircraft this technology would be of limited use. Also, the HMD would be good for A/A targets and slaving of IR missile seeker heads, much the same as the Soviet IRST system today."
S4: "Again by positioning sensors or by the sensors positioning my eyes to the TGT."

5. The HMD would ________ my ability to EMPLOY WEAPONS.

RATING	NUMBER OF RESPONSES
1. Substantially Enhance	1
2. Somewhat Enhance	2
3. Not Affect	1
4. Somewhat Degrade	0
5. Substantially Degrade	0

HOW?

S1: "Better TGT acquisition, and much improved confidence / safety during escape maneuvers."
S2: "Acquisition of the target. But since the jet has to point at the target to release anyway, the HUD/FLIR is still effective."
S3: "In the final phases of weapons employment the pilot is "heads up". By allowing him to look around (check six) and still see if he is on heading and altitude would be great. This could alleviate "tgt fixation". This is assuming a "system" delivery. Being able to confirm the Master Arm is ON without looking in the HUD or making sure all ordinance released (i.e., not hung) without looking down on the PACS page is very good."
S4: No comment

6. The HMD would ________ my SITUATIONAL AWARENESS during the INGRESS PHASE of the mission.

RATING	NUMBER OF RESPONSES
1. Substantially Enhance	1
2. Somewhat Enhance	0
3. Not Affect	2
4. Somewhat Degrade	0
5. Substantially Degrade	0

(Subject 1: NO RATING)

HOW?

S1: No comment
S2: "Previous reasons, visibility REF # 2, 4"
S3: No comment
S4: No comment

7. The HMD would ________my SITUATIONAL AWARENESS during the ATTACK PHASE of the mission.

RATING	NUMBER OF RESPONSES
1. Substantially Enhance	1
2. Somewhat Enhance	3
3. Not Affect	0
4. Somewhat Degrade	0
5. Substantially Degrade	0

HOW?

S1: No comment
S2: Targets are easier to locate from big to small. With current systems all you see is immediate vicinity thereby dumping all other cues. With increased vision and info off boresight my ability to maintain awareness is increased.
S3: Allow me to be more "heads out" in the threat area.
S4: Again, it would free the pilot up from having to look straight ahead through the HUD.. This would be extremely helpful if it had 120o or 180o of use i.e., being able to fly perpendicular to a target and being able to see it through some kind of video picture.

8. The HMD would _______ my SITUATIONAL AWARENESS during the EGRESS PHASE of the mission.

RATING	NUMBER OF RESPONSES
1. Substantially Enhance	1
2. Somewhat Enhance	2
3. Not Affect	1
4. Somewhat Degrade	0
5. Substantially Degrade	0

HOW?

S1: No comment
S2: See # 7.
S3: No comment
S4: "It would allow me to get back down to low altitude faster, by letting me scan out the side of the jet for obstructions, so I can safely exceed TF limits."

9. The HMD would _________ my overall MISSION EFFECTIVENESS.

RATING	NUMBER OF RESPONSES
1. Substantially Enhance	2
2. Somewhat Enhance	0
3. Not Affect	2
4. Somewhat Degrade	0
5. Substantially Degrade	0

HOW?

S1: No comment
S2: Better opportunity to terrain mask, acquire tgt and maintain SA due to increased vision and bigger picture.
S3: For all the reasons stated above. I must stress though that none of the advantages would be worth it if helmet is heavy (long missions fatigue, pulling G's - break neck, loose sight of enemy) or if it restricts the pilots vision by mechanical devices. Looking through small, near combining glasses would be acceptable if visual acuity does not suffer any more than it would looking through a HUD. Also, accurate boresighting of a helmet mounted reticle for consistent wpns employment seems extremely difficult.
S4: "If it allowed me to lockon to tgts visually up to 360o this would be a big help. Also if it could give me a big increase in my off boresight shooting ability of A/A SRM's"

II. 3-D Audio - Based on the implementation of 3-D Audio in the ATC air interdiction mission narrative, please enter your rating in the blank using the following scale. Use the conceptual F-15E single seat cockpit as a basis for comparison:

10. The 3-D audio system would ________ my ability to NAVIGATE.

RATING	NUMBER OF RESPONSES
1. Substantially Enhance	0
2. Somewhat Enhance	1
3. Not Affect	3
4. Somewhat Degrade	0
5. Substantially Degrade	0

HOW?

S1: " Can't envision how it would help get from point to point."
S2: "EX - "Terrain" could be sounded in the direction of terrain within certain criteria to enhance SA. Similar to LANTIRN where terrain is flashed in the HUD to inform you not to attempt turn into terrain. The HUD allows you to see this terrain however so this audio is not mandatory."
S3: No comment
S4: No comment

11. The 3-D audio system would ________ my ability to MANAGE THREATS.

RATING	NUMBER OF RESPONSES
1. Substantially Enhance	3
2. Somewhat Enhance	1
3. Not Affect	0
4. Somewhat Degrade	0
5. Substantially Degrade	0

HOW?

S1: If you can "see it" you can "beat it" (usually) and I envision 3-D audio as a way to get eyes on threat fast.
S2: "EX - Audio that could accurately (+\- 10o) sound direction and type of threat and volume to indicate range would be great."
S3: "Anything that can more quickly get my eyes onto a threat to assess it is a big advantage."
S4: "By giving me range cues or position cues as to where to look for threats. But I would much rather have hard data on my RAW scope (i.e., air threat at 20 miles 5o high). Audio would only be helpful if it was combined with a TEWS system like I described above."

12. The 3-D audio system would ________ my SITUATIONAL AWARENESS during the INGRESS PHASE of the mission.

RATING	NUMBER OF RESPONSES
1. Substantially Enhance	1
2. Somewhat Enhance	1
3. Not Affect	2
4. Somewhat Degrade	0
5. Substantially Degrade	0

HOW?

S1: "Position update of package assets"
S2: "See 10, 11."
S3: "Only in as much as to tell me where in the cockpit to look for caution/warning indications. This enhancement would be minimal considering the technology required to make it work."
S4: No comment

13. The 3-D audio system would ________ my SITUATIONAL AWARENESS during the ATTACK PHASE of the mission.

RATING	NUMBER OF RESPONSES
1. Substantially Enhance	1
2. Somewhat Enhance	1
3. Not Affect	2
4. Somewhat Degrade	0
5. Substantially Degrade	0

HOW?

S1: No comment
S2: "When attention is divided between displays audio of threats can still be understood. Audio is one of the stronger senses."
S3: "Other then for threat management (i.e., someone is shooting at me) the last thing I need is more information piping in my ears during an attack. Pilot workload is at a peak, concentration is high. Anything that would break that concentration in this phase that is not life threatening would be bad. The current 1-D audio is sufficient for this phase of flight. Significant SA building through 3-D audio (other then threats would be minimal."
S4: No comment

14. The 3-D audio system would ________ my SITUATIONAL AWARENESS during the EGRESS PHASE of the mission.

RATING	NUMBER OF RESPONSES
1. Substantially Enhance	1
2. Somewhat Enhance	1
3. Not Affect	2
4. Somewhat Degrade	0
5. Substantially Degrade	0

HOW?

S1: "Same as Ingress."
S2: "See 10, 11"
S3: "See comments for question 12"
S4: No comment

5. The 3-D audio system would ________ my overall MISSION EFFECTIVENESS.

RATING	NUMBER OF RESPONSES
1. Substantially Enhance	1
2. Somewhat Enhance	2
3. Not Affect	1
4. Somewhat Degrade	0
5. Substantially Degrade	0

HOW?

S1: "Biggest advantage would be threat avoidance / defeat."
S2: "See all previous - High SA because of these reasons and idea of where threat, wingman, etc. are at."
S3: "Other then the threat awareness capabilities, 3-D audio seems of only limited advance to the current system."
S4: "Most of the enhancement I can think of is with the TEWS. The rest of what was described like cautions alerting you to a system located in a particular place in the jet aren't very necessary. You learn quickly where everything is located. Example: would you need 3-D audio in your car to position you to where your light switch was? Probably not after the first time you needed to turn the lights on. I'm not decided on the issue of using it to let you know where your wingman was. You would have to test that and see how it works to improve SA."

III. Speech Recognition - Based on the implementation of Speech Recognition in the ATC air interdiction mission narrative, please enter your rating in the blank using the following scale. Use the conceptual F-15E single seat cockpit as a basis for comparison:

16. The speech recognition system would ______ my ability to REPLAN THE MISSION INFLIGHT.

RATING	NUMBER OF RESPONSES
1. Substantially Enhance	1
2. Somewhat Enhance	3
3. Not Affect	0
4. Somewhat Degrade	0
5. Substantially Degrade	0

HOW?

S1: "Hands off ability to transfer data."
S2: " With other technology (data link) voice would not be crucial. Unless (dream on) the computer could understand almost everything i.e., "Bingo - 3000" "Allow - 500" where almost everything could be entered by voice."
S3: " If, as in the narrative, you could "accept" the mission information inflight great. Also need capability to change mission SP/PLAN by voice"
S4: "Save time manually inputting data."

17. The speech recognition system would ______ my SITUATIONAL AWARENESS during the INGRESS PHASE of the mission.

RATING	NUMBER OF RESPONSES
1. Substantially Enhance	0
2. Somewhat Enhance	2
3. Not Affect	2
4. Somewhat Degrade	0
5. Substantially Degrade	0

HOW?

S1: "Hands off changing of displays / master modes."
S2: "Systems are set - no real changes necessary that could enhance SA."
S3: "Can't see how SA would be affected by speech recognition."
S4: "Free up time currently being used to make manual inputs."

18. The speech recognition system would _________ my SITUATIONAL AWARENESS during the ATTACK PHASE of the mission.

RATING	NUMBER OF RESPONSES
1. Substantially Enhance	0
2. Somewhat Enhance	1
3. Not Affect	3
4. Somewhat Degrade	0
5. Substantially Degrade	0

HOW?

S1: No comment
S2: "Change master mode and ordnance. Not critical since I can set up aircraft now to change between modes I need HOTAS."
S3: "Same. Also, many cockpit actions can be accomplished quicker by hand saying them. Chaff, flare dispensing is just a push of my little finger much faster than me saying "dispense chaff, dispense flare", especially if I'm dispensing multiple bundles. Also, what if in the heat of battle, say a dog fight - I can't remember the name of what the little hot things are that decoy missiles (flares). Obviously there would be a manual backup."
S4: No comment

19. The speech recognition system would ________ my SITUATIONAL AWARENESS during the EGRESS PHASE of the mission.

RATING	NUMBER OF RESPONSES
1. Substantially Enhance	0
2. Somewhat Enhance	3
3. Not Affect	1
4. Somewhat Degrade	0
5. Substantially Degrade	0

HOW?

S1: "Same as ingress"
S2: "See 18."
S3: "See 17.
S4: "Again freeing up manual inputs. Could it be used to lock up tgts on your RDR? Could it sort tgts accurately? Can it ID tgts for you."

20. The speech recognition system would ________ my overall MISSION EFFECTIVENESS.

RATING	NUMBER OF RESPONSES
1. Substantially Enhance	0
2. Somewhat Enhance	4
3. Not Affect	0
4. Somewhat Degrade	0
5. Substantially Degrade	0

HOW?

S1: "Decrease the "time necessary" to accomplish tasks in cockpit & decrease task saturation."
S2: "Could be useful to change Master Modes, command lock on etc., but these can be done HOTAS for the most part. Data entry would/could be a big benefit."
S3: "Replanning mission as in the narrative would be great. Changing radio / TACAN / ILS frequencies would be good. As far as other applications that effect the mission, only limited uses here. Machine - human coupling seems like a real interface nightmare especially considering the vocabulary of today's fighter pilot."
S4: "It would definitely help by freeing up lots of time. Realize this would require a whole new type of flight training where pilots would have to verbalize most of what they do."

IV. Sensor Fusion - Based on the implementation of the Integrated Air to Ground Sensor (Sensor Fusion) in the ATC air interdiction mission narrative, please enter your rating in the blank using the following scale. Use the conceptual F-15E single seat cockpit as a basis for comparison:

21. The Sensor Fusion system would ________ my ability to FLY THE AIRCRAFT.

RATING	NUMBER OF RESPONSES
1. Substantially Enhance	3
2. Somewhat Enhance	1
3. Not Affect	0
4. Somewhat Degrade	0
5. Substantially Degrade	0

HOW?

S1: "Ability to see ground in weather."
S2: "Is it tied into the HMD? The more I know about the terrain and my position the easier and better it is."
S3: "Fusing the NAV/FLIR imagery with millimeter wave technology would enhance resolution on low level flights at night."
S4: "By improving the FLIR pictures and allowing to see through clouds."

22. The Sensor Fusion system would ________ my ability to NAVIGATE.

RATING	NUMBER OF RESPONSES
1. Substantially Enhance	3
2. Somewhat Enhance	0
3. Not Affect	1
4. Somewhat Degrade	0
5. Substantially Degrade	0

HOW?

S1: "Display of threats along route & suggested route to avoid them."
S2: "Knowledge of terrain and ability to see it."
S3: No comment
S4: "Same as above."

23. The Sensor Fusion system would Subject __________ my ability to MANAGE THREATS.

RATING	NUMBER OF RESPONSES
1. Substantially Enhance	1
2. Somewhat Enhance	1
3. Not Affect	2
4. Somewhat Degrade	0
5. Substantially Degrade	0

HOW?

S1: "See 22, plus see ground in wx."
S2: "If it contributes to visually acquiring a threat."
S3: No comment
S4: No comment

24. The Sensor Fusion system would __________ my ability to ACQUIRE TARGETS.

RATING	NUMBER OF RESPONSES
1. Substantially Enhance	4
2. Somewhat Enhance	0
3. Not Affect	0
4. Somewhat Degrade	0
5. Substantially Degrade	0

HOW?

S1: "Auto tgt acquisition."
S2: "Better picture - more likely to see it."
S3: "Many times the targeting pod is limited by thermal cross over, where target IR energy and background IR energy is about equal. Anything that could enhance this washed out picture would be good. Also, through night visual deliveries using the NAV/FLIR through the HUD, this technology would help."
S4: "Same as 21 & 22."

25. The Sensor Fusion system would ___________ my ability to EMPLOY WEAPONS.

RATING	NUMBER OF RESPONSES
1. Substantially Enhance	1
2. Somewhat Enhance	1
3. Not Affect	2
4. Somewhat Degrade	0
5. Substantially Degrade	0

HOW?

S1: "Thru better tgt selection (tactical targets)."
S2: "Employment is mostly mechanical if I have already acquired it."
S3: "Once acquired, the employment of the weapons does not seem to be enhanced by this technology."
S4: "Easier tgt recognition would allow greater standoff ranges."

26. The Sensor Fusion system would _________ my SITUATIONAL AWARENESS during the INGRESS PHASE of the mission.

RATING	NUMBER OF RESPONSES
1. Substantially Enhance	2
2. Somewhat Enhance	2
3. Not Affect	0
4. Somewhat Degrade	0
5. Substantially Degrade	0

HOW?

S1: No comment
S2: "See 21"
S3: "Clearer picture of ground and threats."
S4: "Better visibility and picture in all kinds of environments."

27. The Sensor Fusion system would ________ my SITUATIONAL AWARENESS during the ATTACK PHASE of the mission.

RATING	NUMBER OF RESPONSES
1. Substantially Enhance	2
2. Somewhat Enhance	2
3. Not Affect	0
4. Somewhat Degrade	0
5. Substantially Degrade	0

HOW?

S1: No comment
S2: 'See 21, 24."
S3: "See 24."
S4: "Free up time trying to ID tgt 's while having bad picture (tgt FLIR). Plus it would eliminate sunrise/sunset attack problems associated with thermal crossover."

28. The Sensor Fusion system would ___________ my SITUATIONAL AWARENESS during the EGRESS PHASE of the mission.

RATING	NUMBER OF RESPONSES
1. Substantially Enhance	1
2. Somewhat Enhance	3
3. Not Affect	0
4. Somewhat Degrade	0
5. Substantially Degrade	0

HOW?

S1: No comment
S2: "See 21."
S3: "By combining many sensors to give a "big picture", this technology would be useful."
S4: "Longer range visual pickups of tgts even at night. This would be a big help for A/A environment you could visually ID a bandit long range day or night in the weather."

29. The Sensor Fusion system would __________ my overall MISSION EFFECTIVENESS.

RATING	NUMBER OF RESPONSES
1. Substantially Enhance	3
2. Somewhat Enhance	1
3. Not Affect	0
4. Somewhat Degrade	0
5. Substantially Degrade	0

HOW?

S1: No comment
S2: "See 21, 24, 23."
S3: "All reasons above. Seems, however that the fusion of different companies hardware into a single source would be near impossible to attain, and once updates to the system were needed this could actually degrade mission effectiveness if not acted upon."
S4: "By giving me better video picture and increasing distances I can see things, plus doing away with situations where the current system just doesn't work."

V. Data Link - Based on the implementation of the Data Link in the ATC air interdiction mission narrative, please enter your rating in the blank using the following scale. Use the conceptual F-15E single seat cockpit as a basis for comparison:

30. The Data Link system would __________ my ability to FLY THE AIRCRAFT.

RATING	NUMBER OF RESPONSES
1. Substantially Enhance	2
2. Somewhat Enhance	0
3. Not Affect	2
4. Somewhat Degrade	0
5. Substantially Degrade	0

HOW?

S1: No comment
S2: "Reduces "heads down" time and allows me more time to fly aircraft."
S3: No comment
S4: "It would free up time spent communicating and receiving information. It would have to be very fast to use or it might become too distracting."

31. The Data Link system would __________ my ability to NAVIGATE.

RATING	NUMBER OF RESPONSES
1. Substantially Enhance	0
2. Somewhat Enhance	1
3. Not Affect	3
4. Somewhat Degrade	0
5. Substantially Degrade	0

HOW?

S1: No comment

S2: "Once I receive the info I would be able to navigate even if I have to manually enter it."

S3: "Allow me to see "big picture" of where everything and everyone is."

S4: No comment

32. Data Link would _________ my ability to ASSESS THREATS.

RATING	NUMBER OF RESPONSES
1. Substantially Enhance	3
2. Somewhat Enhance	1
3. Not Affect	0
4. Somewhat Degrade	0
5. Substantially Degrade	0

HOW?

S1: "See 22."

S2: "SA on threat locations as they change or as other aircraft have encountered them."

S3: "JTIDS is coming along, but by giving the pilot the ability to "see" threats and threat rings on a TSD along with route would be great for SA."

S4: "Constant updates of threats. Only as good as the information you are data linked. If the information doesn't get passed to you it doesn't matter."

33. Data Link would _________ my ability to REPLAN THE MISSION INFLIGHT.

RATING	NUMBER OF RESPONSES
1. Substantially Enhance	4
2. Somewhat Enhance	0
3. Not Affect	0
4. Somewhat Degrade	0
5. Substantially Degrade	0

HOW?

S1: "Obvious."

S2: "Less time, less heads down more info."

S3: "No - comm replanning without having to wait on voice recognition and authentication would be a big plus. All sorts of info could be data linked without a word spoken and the pilot could actually recall info on a screen if needed."

S4: "I could give you all the new info in a second or two, and you could input it at your pace and it would be clear so you wouldn't have to ask for it to be repeated. "

34. Data Link would ________ my ability to ACQUIRE TARGETS.

RATING	NUMBER OF RESPONSES
1. Substantially Enhance	1
2. Somewhat Enhance	0
3. Not Affect	3
4. Somewhat Degrade	0
5. Substantially Degrade	0

HOW?

S1: No comment
S2: "Once info is loaded that's all that can be done. Data link cannot find the target. However, if location was initially vague - 1st plane thru could data link location to following aircraft."
S3: "Only as far as replanning and updates go."
S4: "It would help alot in the A/A role, seeing where everyone is and who is sorted to who."

35. Data Link would ________ my ability to EMPLOY WEAPONS.

RATING	NUMBER OF RESPONSES
1. Substantially Enhance	0
2. Somewhat Enhance	0
3. Not Affect	4
4. Somewhat Degrade	0
5. Substantially Degrade	0

HOW?

S1: No comment
S2: "See 34"
S3: No comment
S4: No comment

36. The Data Link would Subject 1 = 1 my SITUATIONAL AWARENESS during the INGRESS PHASE of the mission.

RATING	NUMBER OF RESPONSES
1. Substantially Enhance	2
2. Somewhat Enhance	2
3. Not Affect	0
4. Somewhat Degrade	0
5. Substantially Degrade	0

HOW?

S1: "Threat Updates."
S2: "New threats/location/status - info from flight members."
S3: "See 31 and 32."
S4: "Give my update to the big picture of where everyone is at this point of time."

37. The Data Link would ________ my SITUATIONAL AWARENESS during the ATTACK PHASE of the mission.

RATING	NUMBER OF RESPONSES
1. Substantially Enhance	1
2. Somewhat Enhance	2
3. Not Affect	1
4. Somewhat Degrade	0
5. Substantially Degrade	0

HOW?

S1: No comment
S2: "See 36."
S3: "See 31 and 32."
S4: "Same as above."

38. The Data Link would _______ my SITUATIONAL AWARENESS during the EGRESS PHASE of the mission.

RATING	NUMBER OF RESPONSES
1. Substantially Enhance	2
2. Somewhat Enhance	2
3. Not Affect	0
4. Somewhat Degrade	0
5. Substantially Degrade	0

HOW?

S1: "See 36."
S2: "See 36."
S3: "See 31 and 32."
S4: "Same as above. We could pass inflight reports without cluttering up the radios for 5 min. or so."

39. Data Link would _______ my overall MISSION EFFECTIVENESS.

RATING	NUMBER OF RESPONSES
1. Substantially Enhance	3
2. Somewhat Enhance	1
3. Not Affect	0
4. Somewhat Degrade	0
5. Substantially Degrade	0

HOW?

S1: "Survivability & easing workload."
S2: "See 36, 30, 1. Adv: Mission planning, threat status, info from flight member."
S3: "The biggest advantage is secure comm information collection and ability to be flexible in flight in a combat environment.."
S4: "Give "big pictures" help with A/A sorting and help with passing information especially long drawn out info such as inflight reports or change of tgts etc. Again this would have to be easy to use and easy to use quickly, and you would have to be able to manage the info easily. Where would it come up MPD or UFC? Would it clutter other thing you were working on? Can you control how much info you want?."

VI. Pilots Associate - Based on the implementation of the Pilots Associate in the ATC air interdiction mission narrative, please enter your rating in the blank using the following scale. Use the conceptual F-15E single seat cockpit as a basis for comparison:

40. The Pilots Associate would ________ my ability to NAVIGATE.

RATING	NUMBER OF RESPONSES
1. Substantially Enhance	1
2. Somewhat Enhance	0
3. Not Affect	3
4. Somewhat Degrade	0
5. Substantially Degrade	0

HOW?

S1: No comment
S2: "Give me more time to navigate - less time spent monitoring other aircraft systems."
S3: No comment
S4: No comment

41. The Pilots Associate would ________ my ability to ASSESS THREATS.

RATING	NUMBER OF RESPONSES
1. Substantially Enhance	1
2. Somewhat Enhance	2
3. Not Affect	1
4. Somewhat Degrade	0
5. Substantially Degrade	0

HOW?

S1: "Avoid missing RWR symbols / warnings."
S2: "Is this part of the 3-D audio system?"
S3: No comment
S4: "It would help tell you about threats and what to do to defeat them, but how does it work. Who's to say what's more important. AAA off the nose or an SA 6 at 6 miles. Now factor in air threats, threat reactions, fuel etc."

42. The Pilots Associate would _______ my ability to REPLAN THE MISSION INFLIGHT.

RATING	NUMBER OF RESPONSES
1. Substantially Enhance	1
2. Somewhat Enhance	2
3. Not Affect	0
4. Somewhat Degrade	1
5. Substantially Degrade	0

HOW?

S1: "The data must already be data linked. Could be previewed on the TSD. I don't need somebody telling me alot of extraneous information."
S2: "If it did fuel and time calculation for you and warned you of low fuel then yes."
S3: "By drawing "best routing" on TSD after data link inputs and placing threats where appropriate."
S4: "Decrease workload."

43. The Pilots Associate would _________ my ability to ACQUIRE THE TARGET.

RATING	NUMBER OF RESPONSES
1. Substantially Enhance	0
2. Somewhat Enhance	0
3. Not Affect	4
4. Somewhat Degrade	0
5. Substantially Degrade	0

HOW?

S1: No comment
S2: "Cannot fly the aircraft for you."
S3: No comment
S4: "Maybe it could enhance if it could help position sensors at proper ranges et proper time thus cutting down the time it takes to setup map sizes, gain levels etc. Auto freeze maps, store maps."

44. The Pilots Associate would ________ my ability to EMPLOY WEAPONS.

RATING	NUMBER OF RESPONSES
1. Substantially Enhance	0
2. Somewhat Enhance	1
3. Not Affect	3
4. Somewhat Degrade	0
5. Substantially Degrade	0

HOW?

S1: "Possibly thru target ID."
S2: "See 43."
S3: No comment
S4: "Could enhance if it could tell you parameters for different attacks if you could not execute the planned attacks. Example - you planned a 10,000' level LGB pass which gives you 25 sec TOF you need at least 11 sec of laser energy on the tgt to guide the bomb. You get to the tgt and have a 3000 ft ceiling can I get 11 sec with this delivery. How low can I release this weapon."

45. The Pilots Associate would _________ my SITUATIONAL AWARENESS during the INGRESS PHASE of the mission.

RATING	NUMBER OF RESPONSES
1. Substantially Enhance	1
2. Somewhat Enhance	3
3. Not Affect	0
4. Somewhat Degrade	0
5. Substantially Degrade	0

HOW?

S1: "Monitor systems."
S2: "Gives more time to pilot to spend on other tasks. Monitors systems for you overall SA increases."
S3: "Keeping me abreast of the aircraft's systems. "Pimping" me in certain phases (i.e. fence check, master arm)."
S4: "Freeing up time."

46. The Pilots Associate would ________ my SITUATIONAL AWARENESS during the ATTACK PHASE of the mission.

RATING	NUMBER OF RESPONSES
1. Substantially Enhance	1
2. Somewhat Enhance	1
3. Not Affect	2
4. Somewhat Degrade	0
5. Substantially Degrade	0

HOW?

S1: No comment
S2: "See 45."
S3: "Same.
S4: "It would help if it frees up work and time."

47. The Pilots Associate would ________my SITUATIONAL AWARENESS during the EGRESS PHASE of the mission.

RATING	NUMBER OF RESPONSES
1. Substantially Enhance	1
2. Somewhat Enhance	2
3. Not Affect	1
4. Somewhat Degrade	0
5. Substantially Degrade	0

HOW?

S1: "See 45."
S2: "See 45."
S3: "Same."
S4: No comment

48. The Pilots Associate would _________my overall MISSION EFFECTIVENESS.

RATING	NUMBER OF RESPONSES
1. Substantially Enhance	1
2. Somewhat Enhance	2
3. Not Affect	1
4. Somewhat Degrade	0
5. Substantially Degrade	0

HOW?

S1: No comment
S2: "See 45, 42, 40."
S3: "As a "elective WSO", the pilot associate would help with monitoring systems. Do not like the idea of it changing screens on its own though or deciding on emissions of my aircraft. I think escape planning is a good thing, i.e. which way is threat free after an attack or an A/A engagement."
S4: "It would help if it frees up time and does some of the work. It's hard for me to envision how this works."

VII. Head Steered Sensor - Based on the implementation of the Head Steered Sensor in the ATC air interdiction mission narrative, please enter your rating in the blank using the following scale. Use the conceptual F-15E single seat cockpit as a basis for comparison:

49. The Head Steered Sensor would __________my ability to FLY THE AIRCRAFT.

RATING	NUMBER OF RESPONSES
1. Substantially Enhance	2
2. Somewhat Enhance	1
3. Not Affect	0
4. Somewhat Degrade	1
5. Substantially Degrade	0

HOW?

S1: "Much like HMD - See ground in direction A/C is going/turning."
S2: "If it is not affected by weather then I can fly anywhere."
S3: "Could confuse what the pilot is actually seeing at night. Example, if he is looking to the right is he seeing what is to the right or what the sensor only sees? I think the potential for disorientation is high."
S4: "Allow me to use the sensors to see out of aircraft in places I can't now."

50. The Head Steered Sensor would __________my ability to NAVIGATE.

RATING	NUMBER OF RESPONSES
1. Substantially Enhance	1
2. Somewhat Enhance	1
3. Not Affect	2
4. Somewhat Degrade	0
5. Substantially Degrade	0

HOW?

S1: "Do not have to "point to see" terrain/landmarks."
S2: "Allows me to see where I am looking."
S3: No comment
S4: No comment

51. The Head Steered Sensor would __________ my ability to ASSESS THREATS.

RATING	NUMBER OF RESPONSES
1. Substantially Enhance	2
2. Somewhat Enhance	1
3. Not Affect	1
4. Somewhat Degrade	0
5. Substantially Degrade	0

HOW?

S1: No comment
S2: "Can I see the threat?"
S3: "See comments for HMD."
S4: "I could lock onto tgts I see visually."

52. The Head Steered Sensor would _________ my ability to REPLAN THE MISSION INFLIGHT.

RATING	NUMBER OF RESPONSES
1. Substantially Enhance	0
2. Somewhat Enhance	0
3. Not Affect	4
4. Somewhat Degrade	0
5. Substantially Degrade	0

HOW?

S1: No comment
S2: "Most of this is data link or inside cockpit work. How do I see inside the cockpit if I have a helmet that always shows something outside or the sensors look where I look?"
S3: No comment
S4: No comment

53. The Head Steered Sensor would _________ my ability to ACQUIRE THE TARGET.

RATING	NUMBER OF RESPONSES
1. Substantially Enhance	3
2. Somewhat Enhance	1
3. Not Affect	0
4. Somewhat Degrade	0
5. Substantially Degrade	0

HOW?

S1: "Ability to scan target area."
S2: "See 50.
S3: "See #4 on HMD."
S4: "See question 51."

54. The Head Steered Sensor would _______ my ability to EMPLOY WEAPONS.

RATING	NUMBER OF RESPONSES
1. Substantially Enhance	2
2. Somewhat Enhance	0
3. Not Affect	2
4. Somewhat Degrade	0
5. Substantially Degrade	0

HOW?

S1: No comment
S2: "See 50."
S3: "See #5 on HMD."
S4: No comment

55. The Head Steered Sensor would _______ my SITUATIONAL AWARENESS during the INGRESS PHASE of the mission.

RATING	NUMBER OF RESPONSES
1. Substantially Enhance	1
2. Somewhat Enhance	2
3. Not Affect	1
4. Somewhat Degrade	0
5. Substantially Degrade	0

HOW?

S1: "See 49."
S2: "See 50."
S3: No comment
S4: "Allowing me to see things out the side of the airplane, and tgt pop up tgts."

56. The Head Steered Sensor would _______ my SITUATIONAL AWARENESS during the ATTACK PHASE of the mission.

RATING	NUMBER OF RESPONSES
1. Substantially Enhance	1
2. Somewhat Enhance	3
3. Not Affect	0
4. Somewhat Degrade	0
5. Substantially Degrade	0

HOW?

S1: "See 49."
S2: "See 50."
S3: "Possibly allow me to see A/A or A/G targets farther out (i.e. narrow field of view, magnification)."
S4: "Same as above."

57. The Head Steered Sensor would _______ my SITUATIONAL AWARENESS during the EGRESS PHASE of the mission.

RATING	NUMBER OF RESPONSES
1. Substantially Enhance	1
2. Somewhat Enhance	2
3. Not Affect	1
4. Somewhat Degrade	0
5. Substantially Degrade	0

HOW?

S1: "See 49."
S2: "See 50."
S3: No comment
S4: "Same as above."

58. The Head Steered Sensor would _______ my overall MISSION EFFECTIVENESS.

RATING	NUMBER OF RESPONSES
1. Substantially Enhance	2
2. Somewhat Enhance	2
3. Not Affect	0
4. Somewhat Degrade	0
5. Substantially Degrade	0

HOW?

S1: No comment
S2: "See 50."
S3: "See #9 on HMD."
S4: "Being able to position sensors by looking at different this is invaluable. Especially if it is combined with a (HMD)-HUD you could get rid of the HUD if you had this."

2. Technology Assessment: Part II (Technology Implementation)

IMPACT ADVANCED TECHNOLOGY QUESTIONNAIRE INSTRUCTIONS PART II

The purpose of this questionnaire is to obtain your recommendations on how advanced technologies can be applied in order to meet the IMPACT mission objectives. Recall that the IMPACT mission requirements are to perform a precision strike mission, against multiple mobile and fixed targets, at night and in adverse weather, in a single seat aircraft.

For each candidate technology, you will be asked to rate the utility of several potential applications and implementations. This list is intended to help you generate additional ideas of your own. Additional open ended questions are included for you to describe your ideas. This is the primary emphasis of the questionnaire. Base your responses on the technology briefing you received during training, any previous experience you may have had with the technology, your operational experience, and the scenarios you have experienced during your participation in this program. Please do not limit your assessment to the F-15E role playing missions or the ATC mission scenario.

If you have any questions or need clarification on any item, please ask the test engineer. If you do not have enough room for all comments, use the back of the forms.

I. HMD

1.) The following list describes potential uses of an HMD. Please rate the degree to which these implementations would improve your ability to perform the IMPACT mission objectives. Enter your rating on the blank using the following scale:

1 Would significantly enhance ability to perform IMPACT mission
2 Would moderately enhance ability to perform IMPACT mission
3 Would neither enhance nor degrade my ability to perform the IMPACT mission
4 Would moderately degrade ability to perform IMPACT mission
5 Would significantly degrade ability to perform IMPACT mission

Ratings **HMD Implementation**

_____ A. Cue the pilot for visual acquisition of reference points (i.e., waypoints, initial points, offset points, target points) outside the HUD Field-Of-View (FOV).

RATING	NUMBER OF RESPONSES
1. Significantly enhance	1
2. Moderately enhance	3
3. Neither enhance nor degrade	0
4. Moderately degrade	0
5. Significantly degrade	0

_____ B. Designate a point of interest outside the HUD FOV (i.e., target , mark point, waypoints).

RATING	NUMBER OF RESPONSES
1. Significantly enhance	3
2. Moderately enhance	1
3. Neither enhance nor degrade	0
4. Moderately degrade	0
5. Significantly degrade	0

_____ C. Off-boresight target designation.

RATING	NUMBER OF RESPONSES
1. Significantly enhance	3
2. Moderately enhance	1
3. Neither enhance nor degrade	0
4. Moderately degrade	0
5. Significantly degrade	0

____ D. Display ownship airspeed and altitude.

RATING	NUMBER OF RESPONSES
1. Significantly enhance	3
2. Moderately enhance	0
3. Neither enhance nor degrade	1
4. Moderately degrade	0
5. Significantly degrade	0

____ E. Display ownship weapon status and attack mode.

RATING	NUMBER OF RESPONSES
1. Significantly enhance	0
2. Moderately enhance	2
3. Neither enhance nor degrade	1
4. Moderately degrade	1
5. Significantly degrade	0

____ F. Off-boresight radar lock-on of airborne targets (assuming improved missiles).

RATING	NUMBER OF RESPONSES
1. Significantly enhance	3
2. Moderately enhance	1
3. Neither enhance nor degrade	0
4. Moderately degrade	0
5. Significantly degrade	0

____ G. Display medium for sensor video (i.e., LANTIRN video, weapon video, etc.).

RATING	NUMBER OF RESPONSES
1. Significantly enhance	3
2. Moderately enhance	0
3. Neither enhance nor degrade	0
4. Moderately degrade	1
5. Significantly degrade	0

____ H. Display ownship attitude.

RATING	NUMBER OF RESPONSES
1. Significantly enhance	3
2. Moderately enhance	1
3. Neither enhance nor degrade	0
4. Moderately degrade	0
5. Significantly degrade	0

S2: "This could be disorienting to have attitude displayed when looking 90° off boresight, cause you will have attitude on a sideway moving picture."

_____ I. Display medium for threat warning symbology.

RATING	NUMBER OF RESPONSES
1. Significantly enhance	1
2. Moderately enhance	2
3. Neither enhance nor degrade	1
4. Moderately degrade	0
5. Significantly degrade	0

S2: "Audio would be better and eliminate some clutter in the HMD."

_____ J. Display medium for warnings and cautions.

RATING	NUMBER OF RESPONSES
1. Significantly enhance	1
2. Moderately enhance	1
3. Neither enhance nor degrade	0
4. Moderately degrade	2
5. Significantly degrade	0

S2: "To cue to look at the cockpit lights - but audio is also good."

2.) Please describe any additional HMD applications or implementations you think would aid in accomplishing the IMPACT mission. When answering this question, consider and describe how the HMD might aid performance of specific mission functions, such as flying the aircraft, communications, navigation, threat management, target acquisition and weapon employment, as appropriate. Also describe how the concepts might reduce workload, improve mission effectiveness or improve situational awareness, if applicable.

Proposed Application or Implementation	**Expected Benefits (Performance, SA, Workload and Effectiveness)**
S1: "3-D presentation of terrain."	*S1: "Fly a/c at night/wx without need of TF systems*
S2: No comment	*S2: No comment*
S3: "Including a color code in the visor/combining glass. Example: if a caution light comes on, the visor would have a yellow hue to it. A threat would have a red hue to it."	*S3: "Increase SA"*
S4: No comment	*S4: No comment*

3.) Do you think an HMD would degrade your ability to successfully perform the IMPACT mission in any way?

RESPONSE	NUMBER OF RESPONSES
______Yes	0
______No	4

If yes, explain.

S4: "But don't clutter it up with too much info. The jet has a caution panel so use it, you have a RWR so use it. You don't need to put everything on the HMD, or at least make it selectable."

II. 3-D Audio

1.) The following list describes potential uses of a 3-D Audio system. Please rate the degree to which these implementations would improve your ability to perform the IMPACT mission objectives. Use the following scale:

1 Would significantly enhance ability to perform IMPACT mission
2 Would moderately enhance ability to perform IMPACT mission
3 Would neither enhance nor degrade my ability to perform the IMPACT mission
4 Would moderately degrade ability to perform IMPACT mission
5 Would significantly degrade ability to perform IMPACT mission

Rating **3-D Audio Implementation**

_____ A. Cue the pilot of threat detection.

RATING	NUMBER OF RESPONSES
1. Significantly enhance	3
2. Moderately enhance	1
3. Neither enhance nor degrade	0
4. Moderately degrade	0
5. Significantly degrade	0

_____ B. Cue the pilot of threat priority (by coupling differences in volume with threat locations)

RATING	NUMBER OF RESPONSES
1. Significantly enhance	1
2. Moderately enhance	3
3. Neither enhance nor degrade	0
4. Moderately degrade	0
5. Significantly degrade	0

_____ C. Cue communication source location to the pilot (i.e., wingman, FAC, etc.).

RATING	NUMBER OF RESPONSES
1. Significantly enhance	1
2. Moderately enhance	1
3. Neither enhance nor degrade	2
4. Moderately degrade	0
5. Significantly degrade	0

_____ D. Cue the pilot to look at a particular location for aircraft system status information.

RATING	NUMBER OF RESPONSES
1. Significantly enhance	0
2. Moderately enhance	2
3. Neither enhance nor degrade	2
4. Moderately degrade	0
5. Significantly degrade	0

S2: "Not that many places to look as far as trying to know where based on audio."

_____ E. Ground Collision Avoidance System audio cue (i.e., cue direction of roll and pull)

RATING	NUMBER OF RESPONSES
1. Significantly enhance	0
2. Moderately enhance	1
3. Neither enhance nor degrade	1
4. Moderately degrade	2
5. Significantly degrade	0

S2: "Very careful of this - this could be easily misinterpreted and cause accidents. OK to have normal audio to warn of low alt, etc."

2.) Please describe any additional 3-D Audio applications or implementations you think would aid in accomplishing the IMPACT mission. When answering this question, consider and describe how the 3-D Audio might aid performance of specific mission functions, such as flying the aircraft, communications, navigation, threat management, target acquisition and weapon employment, as appropriate. Also describe how the concepts might reduce workload, improve mission effectiveness or improve situational awareness, if applicable.

Proposed Application or Implementation	**Expected Benefits (Performance, SA, Workload and Effectiveness)**
S1: No comment *S2: Use audio to tell of* TYPE *of threat, i.e., SA-3."* *S3: No comment* *S4: No comment*	*S1: No comment* *S2: No comment* *S3: No comment* *S4: No comment*

3.) Do you think 3-D Audio would degrade your ability to successfully perform the IMPACT mission in any way?

RESPONSE	NUMBER OF RESPONSES
______Yes	2
______No	2

If yes, explain.

S1: "Ground collision avoidance could actually be disorienting depending on your head (or helmet) orientation when activated.

S3: "Information overload in target area could be a problem if 3-D audio starts with something other than a life threatening input.

S4: "The things I indicated I don't think are necessary."

III. Speech Recognition

1.) The following list describes potential uses of a Speech Recognition system. Please rate the degree to which these implementations would improve your ability to perform the IMPACT mission objectives. Enter your rating on the blank using the following scale:

1 Would significantly enhance ability to perform IMPACT mission
2 Would moderately enhance ability to perform IMPACT mission
3 Would neither enhance nor degrade my ability to perform the IMPACT mission
4 Would moderately degrade ability to perform IMPACT mission
5 Would significantly degrade ability to perform IMPACT mission

Rating **Speech Recognition**

_____ A. Voice selection and input of TACAN modes.

RATING	NUMBER OF RESPONSES
1. Significantly enhance	0
2. Moderately enhance	4
3. Neither enhance nor degrade	0
4. Moderately degrade	0
5. Significantly degrade	0

_____ B. Voice selection and input of radio frequencies.

RATING	NUMBER OF RESPONSES
1. Significantly enhance	1
2. Moderately enhance	3
3. Neither enhance nor degrade	0
4. Moderately degrade	0
5. Significantly degrade	0

_____ C. Voice selection and input of terrain following altitudes.

RATING	NUMBER OF RESPONSES
1. Significantly enhance	0
2. Moderately enhance	2
3. Neither enhance nor degrade	1
4. Moderately degrade	1
5. Significantly degrade	0

S2: "Need to verify anyway - I would not want to speak and then believe it happened so I may as well push a button to know I did."

_____ D. Voice selection and input of IFF modes/codes.

RATING	NUMBER OF RESPONSES
1. Significantly enhance	0
2. Moderately enhance	3
3. Neither enhance nor degrade	1
4. Moderately degrade	0
5. Significantly degrade	0

_____ E. Voice selection and input of target coordinates and elevation.

RATING	NUMBER OF RESPONSES
1. Significantly enhance	0
2. Moderately enhance	4
3. Neither enhance nor degrade	0
4. Moderately degrade	0
5. Significantly degrade	0

_____ F. Voice selection of system status checks.

RATING	NUMBER OF RESPONSES
1. Significantly enhance	1
2. Moderately enhance	1
3. Neither enhance nor degrade	2
4. Moderately degrade	0
5. Significantly degrade	0

_____ G. Voice control of countermeasures (i.e., chaff/flares, ECM).

RATING	NUMBER OF RESPONSES
1. Significantly enhance	2
2. Moderately enhance	1
3. Neither enhance nor degrade	1
4. Moderately degrade	0
5. Significantly degrade	0

_____ H. Voice selection and input of navigation updates.

RATING	NUMBER OF RESPONSES
1. Significantly enhance	0
2. Moderately enhance	4
3. Neither enhance nor degrade	0
4. Moderately degrade	0
5. Significantly degrade	0

_____ I. Voice selection and input of mark points.

RATING	NUMBER OF RESPONSES
1. Significantly enhance	1
2. Moderately enhance	2
3. Neither enhance nor degrade	1
4. Moderately degrade	0
5. Significantly degrade	0

_____ J. Voice selection of MPD formats.

RATING	NUMBER OF RESPONSES
1. Significantly enhance	1
2. Moderately enhance	0
3. Neither enhance nor degrade	3
4. Moderately degrade	0
5. Significantly degrade	0

_____ K. Voice selection of master modes.

RATING	NUMBER OF RESPONSES
1. Significantly enhance	1
2. Moderately enhance	1
3. Neither enhance nor degrade	2
4. Moderately degrade	0
5. Significantly degrade	0

2.) Please describe any additional Speech Recognition applications or implementations you think would aid in accomplishing the IMPACT mission. When answering this question, consider and describe how Speech Recognition might aid performance of specific mission functions, such as flying the aircraft, communications, navigation, threat management, target acquisition and weapon employment, as appropriate. Also describe how the concepts might reduce workload, improve mission effectiveness or improve situational awareness, if applicable.

Proposed Application or Implementation	Expected Benefits (Performance, SA, Workload and Effectiveness)
S1: "Control of fire control systems (radar, tgt pod, etc.)	*S1: "Coupled with HMD, could reduce workload of off-boresight lock ons, tgt pod lock ons & employment of weapons."*
S2: "For mission data - coord, fuel bingo, etc. There is no limit to how much could be voice loaded."	*S2: "Reduced workload for changed mission profile."*
S3: "For Head Steered Sensor: being able to verbalize a narrow field of view or magnify."	*S3: "Early A/A or A/G target ID."*
S4: "Use for setting up rdr display."	*S4: "Lots of switch activations are currently required."*

3.) Do you think Speech Recognition would degrade your ability to successfully perform the IMPACT mission in any way?

RESPONSE	NUMBER OF RESPONSES
______Yes	3
______No	1

If yes, explain.

S1: "Possibility of either saying something you did not intend to, or miss interpretation of voice commands."

S3: "The terrain clearance selection by voice is not a good idea. Since this is extremely important, the pilot needs the reinforcement of actually setting a clearance plane himself. Just saying it is not enough."

S4: "If you make too many systems voice dependent you will start missing very important comm. It's hard to talk and listen at the same time."

IV. Sensor Fusion

1.) The following list describes potential uses of a sensor fusion system. Please rate the degree to which these implementations would improve your ability to perform the IMPACT mission objectives. Enter your rating on the blank using the following scale:

1 Would significantly enhance ability to perform IMPACT mission
2 Would moderately enhance ability to perform IMPACT mission
3 Would neither enhance nor degrade my ability to perform the IMPACT mission
4 Would moderately degrade ability to perform IMPACT mission
5 Would significantly degrade ability to perform IMPACT mission

Rating **Sensor Fusion**

_____ A. Synthetically (via computer) generating a display based on sensor imagery data from multiple sensors (i.e., radar, millimeter wave radar, FLIR, etc.).

RATING	NUMBER OF RESPONSES
1. Significantly enhance	3
2. Moderately enhance	1
3. Neither enhance nor degrade	0
4. Moderately degrade	0
5. Significantly degrade	0

_____ B. Overlay sensor imagery over each other to form one composite image.

RATING	NUMBER OF RESPONSES
1. Significantly enhance	3
2. Moderately enhance	1
3. Neither enhance nor degrade	0
4. Moderately degrade	0
5. Significantly degrade	0

_____ C. Maintain a single sensor format (i.e., independent formats for radar, FLIR, millimeter wave radar etc.).

RATING	NUMBER OF RESPONSES
1. Significantly enhance	1
2. Moderately enhance	2
3. Neither enhance nor degrade	1
4. Moderately degrade	0
5. Significantly degrade	0

_____ D. Display best possible fused image, with the capability for the pilot to switch to a single sensor.

RATING	NUMBER OF RESPONSES
1. Significantly enhance	4
2. Moderately enhance	0
3. Neither enhance nor degrade	0
4. Moderately degrade	0
5. Significantly degrade	0

2.) Please describe any additional Sensor Fusion applications or implementations you think would aid in accomplishing the IMPACT mission. When answering this question, consider and describe how Sensor Fusion might aid performance of specific mission functions, such as flying the aircraft, communications, navigation, threat management, target acquisition and weapon employment, as appropriate. Also describe how the concepts might reduce workload, improve mission effectiveness or improve situational awareness, if applicable.

Proposed Application or Implementation	**Expected Benefits (Performance, SA, Workload and Effectiveness)**
S1: No comment	*S1: No comment*
S2: "Unless the system is close to automatic the pilot would not have time to look at all sensors and pick which one. Needs to be almost automatic with ability to switch to single sensor."	*S2: "If not done - increased workload."*
S3: No comment	*S3: No comment*
S4: No comment	*S4: No comment*

3.) Do you think Sensor Fusion would degrade your ability to successfully perform the IMPACT mission in any way?

RESPONSE	NUMBER OF RESPONSES
______Yes	1
______No	3

If yes, explain.

S1: "Selecting a target that you did not want to engage & taking time to reject or step thru to correct/desired target."

S4: "You need to have the ability to select a certain sensor or all sensors."

V. Data Link

1.) The following list describes potential uses of a Data Link system. Please rate the degree to which these implementations would improve your ability to perform the IMPACT mission objectives. Enter your rating on the blank using the following scale:

1 Would significantly enhance ability to perform IMPACT mission
2 Would moderately enhance ability to perform IMPACT mission
3 Would neither enhance nor degrade my ability to perform the IMPACT mission
4 Would moderately degrade ability to perform IMPACT mission
5 Would significantly degrade ability to perform IMPACT mission

Rating **Data Link**

_____ A. Secure, non-voice method of inflight mission retasking/replanning.

RATING	NUMBER OF RESPONSES
1. Significantly enhance	3
2. Moderately enhance	1
3. Neither enhance nor degrade	0
4. Moderately degrade	0
5. Significantly degrade	0

_____ B. Secure, real-time method for intelligence updates.

RATING	NUMBER OF RESPONSES
1. Significantly enhance	4
2. Moderately enhance	0
3. Neither enhance nor degrade	0
4. Moderately degrade	0
5. Significantly degrade	0

_____ C. Graphical display of enemy and friendly ground troops in the target area.

RATING	NUMBER OF RESPONSES
1. Significantly enhance	3
2. Moderately enhance	1
3. Neither enhance nor degrade	0
4. Moderately degrade	0
5. Significantly degrade	0

S2: "Depends on how much and where - don't overwhelm pilot with useless info."

_____ D. Capability for aircraft to share information comm out (weapons remaining, fuel status, etc.).

RATING	NUMBER OF RESPONSES
1. Significantly enhance	1
2. Moderately enhance	2
3. Neither enhance nor degrade	1
4. Moderately degrade	0
5. Significantly degrade	0

_____ E. Targeting of enemy aircraft formations by graphically displaying which friendly fighter in the formation is locked to which bandit.

RATING	NUMBER OF RESPONSES
1. Significantly enhance	2
2. Moderately enhance	2
3. Neither enhance nor degrade	0
4. Moderately degrade	0
5. Significantly degrade	0

_____ F. Other platforms (JSTARS, AWACS, another fighter) could confirm a contact as a bandit without the fighter interrogating it.

RATING	NUMBER OF RESPONSES
1. Significantly enhance	4
2. Moderately enhance	0
3. Neither enhance nor degrade	0
4. Moderately degrade	0
5. Significantly degrade	0

2.) Please describe any additional Data Link applications or implementations you think would aid in accomplishing the IMPACT mission. When answering this question, consider and describe how Data Link might aid performance of specific mission functions, such as flying the aircraft, communications, navigation, threat management, target acquisition and weapon employment, as appropriate. Also describe how the concepts might reduce workload, improve mission effectiveness or improve situational awareness, if applicable.

Proposed Application or Implementation	Expected Benefits (Performance, SA, Workload and Effectiveness)
S1: "Display enemy/friendly a/c on scope outside of your a/c radar coverage or range."	*S1: "SA builder"*
S2: No comment	*S2: No comment*
S3: No comment	*S3: No comment*
S4: "Use data link to send satellite picture or photos of tgt area."	*S4: "Help ensure proper tgt is targeted."*

3.) Do you think Data Link would degrade your ability to successfully perform the IMPACT mission in any way?

RESPONSE	NUMBER OF RESPONSES
______Yes	1
______No	3

If yes, explain.

S4: "If it is used by people sitting 300 miles from the conflict to control what is going on."

VI. Pilot's Associate

1.) The following list describes potential uses of a Pilot's Associate system. Please rate the degree to which these implementations would improve your ability to perform the IMPACT mission objectives. Enter your rating on the blank using the following scale:

1 Would significantly enhance ability to perform IMPACT mission
2 Would moderately enhance ability to perform IMPACT mission
3 Would neither enhance nor degrade my ability to perform the IMPACT mission
4 Would moderately degrade ability to perform IMPACT mission
5 Would significantly degrade ability to perform IMPACT mission

Rating **Pilot's Associate**

_____ A. Display of current aircraft status information on single format.

RATING	NUMBER OF RESPONSES
1. Significantly enhance	1
2. Moderately enhance	2
3. Neither enhance nor degrade	1
4. Moderately degrade	0
5. Significantly degrade	0

_____ B. Cue the pilot to system anomalies and display a plan to address these problems.

RATING	NUMBER OF RESPONSES
1. Significantly enhance	1
2. Moderately enhance	3
3. Neither enhance nor degrade	0
4. Moderately degrade	0
5. Significantly degrade	0

_____ C. Computer generated routes based on mission redirect/retasking.

RATING	NUMBER OF RESPONSES
1. Significantly enhance	1
2. Moderately enhance	3
3. Neither enhance nor degrade	0
4. Moderately degrade	0
5. Significantly degrade	0

_____ D. Computer generated tactic plans (i.e., SAM avoidance) in response to dynamic mission events (i.e., pop-up SAMs).

RATING	NUMBER OF RESPONSES
1. Significantly enhance	1
2. Moderately enhance	3
3. Neither enhance nor degrade	0
4. Moderately degrade	0
5. Significantly degrade	0

S2: "Possibly too much info to quickly review - overwhelm pilot with info."

2.) Please describe any additional Pilot's Associate applications or implementations you think would aid in accomplishing the IMPACT mission. When answering this question, consider and describe how a Pilot's Associate system might aid performance of specific mission functions, such as flying the aircraft, communications, navigation, threat management, target acquisition and weapon employment, as appropriate. Also describe how the concepts might reduce workload, improve mission effectiveness or improve situational awareness, if applicable.

Proposed Application or Implementation	**Expected Benefits (Performance, SA, Workload and Effectiveness)**
S1: No comment *S2: "Checklist procedures on screen or audio."* *S3: No comment* *S4: "Weapon planning as I described in Section I."*	*S1: No comment* *S2: "Effective way to deal with critical emergencies."* *S3: No comment* *S4: "Have knowledge in the jet beyond what anyone could memorize."*

3.) Do you think Pilot's Associate would degrade your ability to successfully perform the IMPACT mission in any way?

RESPONSE	NUMBER OF RESPONSES
______Yes	2
______No	2

If yes, explain.

S1: "Running commentary between PA and pilot leaves little time for comm between outside assets/agencies."

S4: "If it overloads you with info, or if it gives you bad information, when it's not sure."

VII. Head Steered Sensor

1.) The following list describes potential uses of a Head Steered Sensor assuming an HMD is incorporated. Please rate the degree to which these implementations would improve your ability to perform the IMPACT mission objectives. Enter your rating on the blank using the following scale:

1 Would significantly enhance ability to perform IMPACT mission
2 Would moderately enhance ability to perform IMPACT mission
3 Would neither enhance nor degrade my ability to perform the IMPACT mission
4 Would moderately degrade ability to perform IMPACT mission
5 Would significantly degrade ability to perform IMPACT mission

Rating **Head Steered Sensor**

_____ A. Point the sensor (i.e., radar, FLIR, etc.)

RATING	NUMBER OF RESPONSES
1. Significantly enhance	3
2. Moderately enhance	0
3. Neither enhance nor degrade	1
4. Moderately degrade	0
5. Significantly degrade	0

_____ B. Point the weapon seeker (i.e., maverick, etc.)

RATING	NUMBER OF RESPONSES
1. Significantly enhance	2
2. Moderately enhance	2
3. Neither enhance nor degrade	0
4. Moderately degrade	0
5. Significantly degrade	0

2.) Please describe any additional Head Steered Sensor applications or implementations you think would aid in accomplishing the IMPACT mission. When answering this question, consider and describe how the Head Steered Sensor might aid performance of specific mission functions, such as flying the aircraft, communications, navigation, threat management, target acquisition and weapon employment, as appropriate. Also describe how the concepts might reduce workload, improve mission effectiveness or improve situational awareness, if applicable.

Proposed Application or Implementation	Expected Benefits (Performance, SA, Workload and Effectiveness)
S1: No comment *S2: No comment* *S3: No comment* *S4: "Give you cues where to look for RWR cues. Tell you where to look for an SA-3 that was just launched at you."*	*S1: No comment* *S2: No comment* *S3: No comment* *S4: "Help defeat threats and look for others. Save lots of time searching for threats."*

3.) Do you think Head Steered Sensor would degrade your ability to successfully perform the IMPACT mission in any way?

RESPONSE	NUMBER OF RESPONSES
______Yes	2
______No	2

If yes, explain.

S1: "Confusion could result thru unintentional or unwanted pointing of sensor or weapon thru head movement."

S3: "See Comments, question 49 Part I.

3. IMPACT Study Questionnaire

IMPACT Study Questionnaire

The following questionnaire, to be completed anonymously unless you care to attach your name for follow-up discussion, was developed so that you could provide feedback to the project team for improving future studies. Your comments are valuable to us and are greatly appreciated!

1. Overall, how would you rate the simulator used in this study?

RATING	NUMBER OF RESPONSES
___Exceptional	0
___Good	2
___Fair	2
___Poor	0
___Unacceptable	0

Do you have any other comments on this topic?

S1: "Use technology available, i.e., auto TF. Scenario mission would be very difficult to accomplish single seat without auto TF."
S2: "However, this is early stages so nothing could be done."
S3: No comment
S4: "It was used to the best of its ability. I think you would do better to use one ot the simulators Luke or Seymour Johnson. That way the HUD is the same and so is the stick, etc."

2. How would you rate the simulator and role-playing methodology for making projective estimates about workload for the air interdiction mission?

RATING	NUMBER OF RESPONSES
___Exceptional	0
___Good	2
___Fair	2
___Poor	0
___Unacceptable	0

Do you have any other comments on this topic?

S1: "Actual air interdiction mission would not be so time compressed."
S2: "As simulator gets better more data could be measured."
S3: "Seems the engineers did their homework on developing a realistic scenario."
S4: "The simulator has you locked into one way of doing things which is not the case in real life."

3. How would you rate the approach of using the single, fixed sequence of mission activities (versus using other sequences or tactics that you might prefer) for making projective estimates about workload?

RATING	NUMBER OF RESPONSES
___Exceptional	2
___Good	1
___Fair	1
___Poor	0
___Unacceptable	0

Do you have any other comments on this topic?

S1: "Everybody will have a different approach for solving a problem, there is no right or wrong way, however, as you alter the pilots' normal sequence of events, workload will necessarily increase."
S2: "Keeps it simple for the pilot."
S3: No comment
S4: No comment

4. How would you rate ProSWAT as a means for assisting you with making projective estimates concerning the workload of mission critical events (completion of mission change inputs, engage ground threats, obtain patch map, weapon employment, and engaging air threats) during the air interdiction mission?

RATING	NUMBER OF RESPONSES
___Exceptional	1
___Good	3
___Fair	0
___Poor	0
___Unacceptable	0

Do you have any other comments on this topic?

S1: No comment
S2: "Simple to do"
S3: No comment
S4: "I would prefer to just tell you right now I don't have free time and am mentally stressed but I know that it would not fit with what you're looking for."

5. How would you rate SWORD as a means for assisting you with making relative judgments about primary mission functions (in-flight replanning, target acquisition, and weapon employment) for the various aircraft configurations (F-15E dual seat, F-15E single seat, and advanced technology cockpit) used in the air interdiction mission?

RATING	NUMBER OF RESPONSES
___Exceptional	1
___Good	3
___Fair	0
___Poor	0
___Unacceptable	0

Do you have any other comments on this topic?

S1: No comment
S2: No comment
S3: No comment
S4: No comment

6. How would you rate the questionnaires and interviews used in this study?

RATING	NUMBER OF RESPONSES
___Exceptional	0
___Good	4
___Fair	0
___Poor	0
___Unacceptable	0

Do you have any other comments on this topic?

S1: No comment
S2: "Realize most answers remain the same for different phases of flight. Generic and even more detailed description of each technology if available."
S3: "Might possibly be a way to combine the role playing questionnaire Parts I and II into one, seems Parts I and II are a bit redundant.
S4: No comment

7. Overall, how would you rate the data collection procedures.

RATING	NUMBER OF RESPONSES
___Exceptional	2
___Good	1
___Fair	1
___Poor	0
___Unacceptable	0

Do you have any other comments on this topic?

S1: "You are asking to "project" into a scenario, which will cause large variations from subject to subject. More objectivity versus subjectivity would help."
S2: "Easy, convenient for me and my simple mind."
S3: No comment
S4: "You can get a lot more info by just talking through stages of flight and asking what are you thinking about, what could help you out."

8. How would you rate the quality of training (briefings, Q&A, hands-on, etc.)?

RATING	NUMBER OF RESPONSES
___Exceptional	1
___Good	2
___Fair	1
___Poor	0
___Unacceptable	0

Do you have any other comments on this topic?

S1: No comment
S2: No comment
S3: "All personnel were professional and polite. Real nice to work with."
S4: No comment

9. How would you rate the "logistics" (e.g. billeting, accommodations, etc.) during your participation in this study?

RATING	NUMBER OF RESPONSES
___Exceptional	1
___Good	3
___Fair	0
___Poor	0
___Unacceptable	0

Do you have any other comments on this topic?

S1: No comment
S2: "Thanks! Appreciate everyone's friendliness."
S3: No comment
S4: No comment

10. How would you rate the staff that conducted this study in terms of knowledge, preparation, and professionalism?

RATING	NUMBER OF RESPONSES
___Exceptional	3
___Good	1
___Fair	0
___Poor	0
___Unacceptable	0

Do you have any other comments on this topic?

S1: No comment
S2: "Outstanding!"
S3: No comment
S4: No comment

11. What parts of the role playing methodology do you think need to be improved and why?

S1: "Use actual simulator with actual threats and possibility of destruction through ground impact, threats, etc."
S2: "As the gameplan emerges start including more stuff - helmet, simulator more like real life to help people realize it will be like."
S3: "Making the displays actually work. The HUD was fine, the other displays need to actually show information, not just a frozen screen. This would allow the test subject to more easily project himself into the role."
S4: "The simulator - make it more realistic and more flexible."

12. Do you have any other comments about this study?

S1: "A better demonstration of advanced techniques through simulator interaction would allow more objective comparisons."
S2: "Glad to be part of it."
S3: "Why not take this "on the road". This would give you a broader data base and have more realistic simulations. Perhaps Luke AFB, F-16 and F-15E simulators are there."
S4: No comment